

KE1X AND TSI INTRODUCTION

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APR, 2017



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SECURE CONNECTIONS
FOR A SMARTER WORLD

Agenda

- **Kinetis E Roadmap and Portfolio**
- **KE1x KEY Features***
 - Robust and Safety
 - Security
 - Comprehensive Peripherals
- **Touch Sensing Introduction**
 - Target in Home Appliance
 - Touch Sensing Basic
 - Technical Support
 - KE15Z TSI Test Report

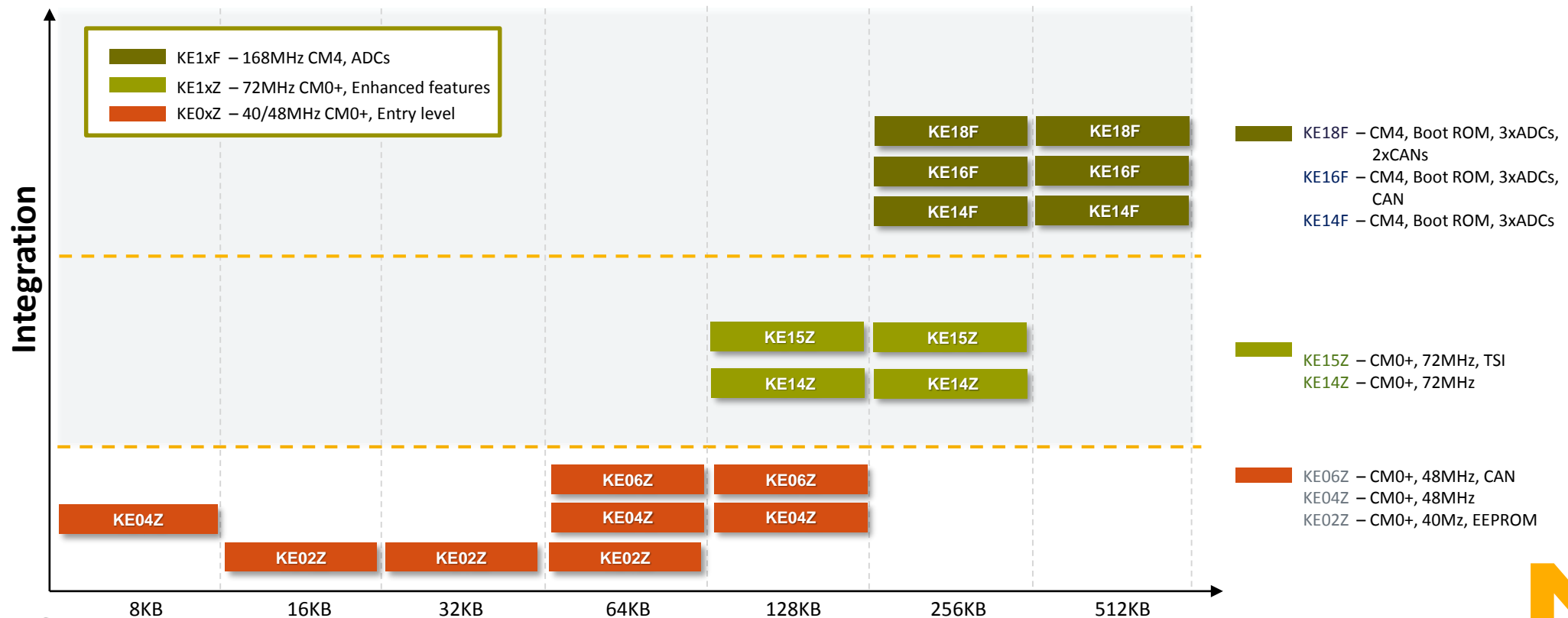
** KE1x refers to KE1xZ (ARM M0+ core) and KE1xF (ARM M4F core)*



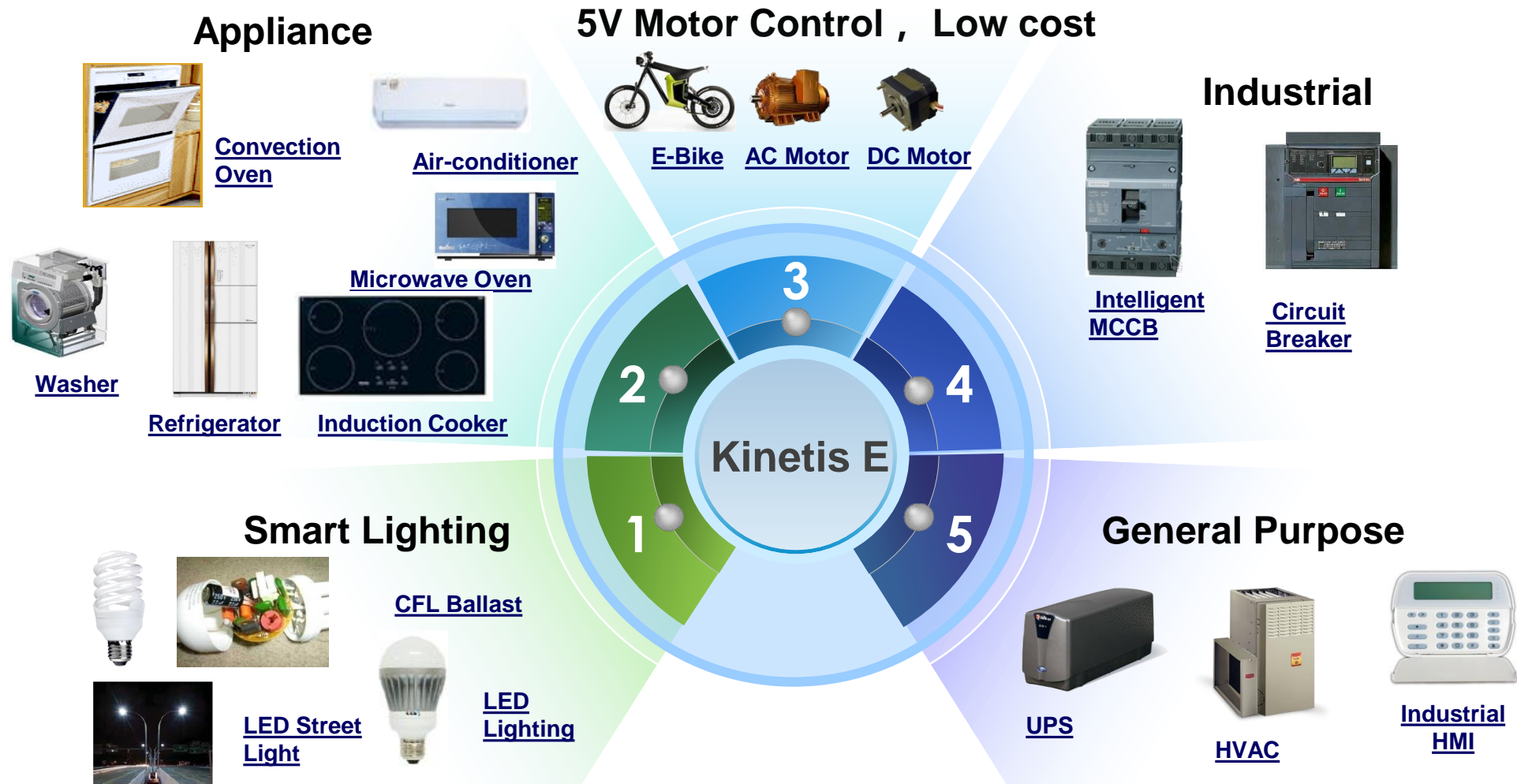
KINETIS E ROADMAP & PORTFOLIO

Kinetis E Series Product Roadmap

- **5V MCU** – Voltage range: 2.7 to 5.5 V, temperature range: –40 to 105 °C
- **Strong Robustness** – Strong noise immunity performance, passed IEC61000-4-2/-4-4/-4-6
- **High Efficiency** – Cortex-M0+ 72MHz / M4F core 168MHz
- **Low Cost** – Reduce overall BOM cost with options for smart on-chip modules
- **Comprehensive Enablement** – Speed application development with NXP ecosystem

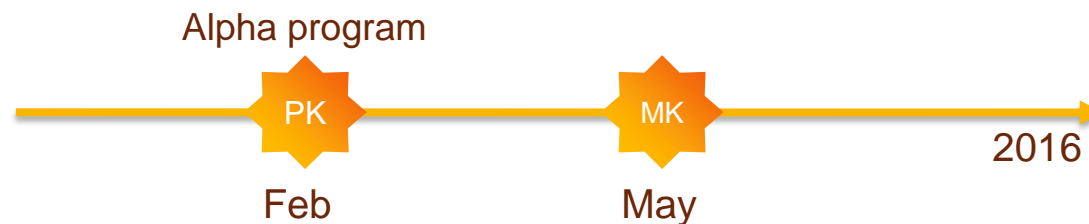


Kinetis E Series Targeted Market & Applications



KE1xZ Parts List - CM0+ @72MHz

Sub-Family	Part Number	CM0+ (MHz)	Memory				Features												64LQFP	100LQFP
			Flash (KB)	SRAM (KB)	EEPROM (KB)	Boot ROM	DMA(ch)	BME	UART	SPI	I2C	TSI	FlexIO	ACMP	FlexTimer	12b ADC	8b DAC	Total # of IOs		
KE14Z	MKE14Z128VLH7	72	128	16	2	Y	8	Y	3	2	2		1	2	3	2	1	58	√	
	MKE14Z128VLL7	72	128	16	2	Y	8	Y	3	2	2		1	2	3	2	1	89		√
	MKE14Z256VLH7	72	256	32	2	Y	8	Y	3	2	2		1	2	3	2	1	58	√	
	MKE14Z256VLL7	72	256	32	2	Y	8	Y	3	2	2		1	2	3	2	1	89		√
KE15Z	MKE15Z128VLH7	72	128	16	2	Y	8	Y	3	2	2	1	1	2	3	2	1	58	√	
	MKE15Z128VLL7	72	128	16	2	Y	8	Y	3	2	2	1	1	2	3	2	1	89		√
	MKE15Z256VLH7	72	256	32	2	Y	8	Y	3	2	2	1	1	2	3	2	1	58	√	
	MKE15Z256VLL7	72	256	32	2	Y	8	Y	3	2	2	1	1	2	3	2	1	89		√



KE1xF Parts List – CM4 @168MHz

Sub-Family	Part Number	CM4F (MHz)	Memory				4Features										64LQFP	100LQFP	
			Flash (KB)	SRAM (KB)	EEPROM (KB)	Boot ROM	DMA(ch)	UART	SPI	I2C	CAN	FlexIO	ACMP	FlexTimer	12bit ADC	12b DAC			Total IOs
KE14F	MKE14F256VLH16	168	256	32	2	Y	16	3	2	2		1	3	4	3	1	58	√	
	MKE14F256VLL16	168	256	32	2	Y	16	3	2	2		1	3	4	3	1	89		√
	MKE14F512VLH16	168	512	64	4	Y	16	3	2	2		1	3	4	3	1	58	√	
	MKE14F512VLL16	168	512	64	4	Y	16	3	2	2		1	3	4	3	1	89		√
KE16F	MKE16F256VLH16	168	256	32	2	Y	16	3	2	2	1	1	3	4	3	1	58	√	
	MKE16F256VLL16	168	256	32	2	Y	16	3	2	2	1	1	3	4	3	1	89		√
	MKE16F512VLH16	168	512	64	4	Y	16	3	2	2	1	1	3	4	3	1	58	√	
	MKE16F512VLL16	168	512	64	4	Y	16	3	2	2	1	1	3	4	3	1	89		√
KE18F	MKE18F256VLH16	168	256	32	2	Y	16	3	2	2	2	1	3	4	3	1	58	√	
	MKE18F256VLL16	168	256	32	2	Y	16	3	2	2	2	1	3	4	3	1	89		√
	MKE18F512VLH16	168	512	64	4	Y	16	3	2	2	2	1	3	4	3	1	58	√	
	MKE18F512VLL16	168	512	64	4	Y	16	3	2	2	2	1	3	4	3	1	89		√



KE1xZ Master Block Diagram

Key Features:

Core/System

- ARM® Cortex®-M0+ up to 72MHz
- 8ch eDMA
- TRGMUX
- MMDVSQ

Memory

- up to 256KB Flash with ECC
- up to 32KB SRAM
- up to 32KB FlexMemory / 2KB EEPROM
- Boot ROM

Communications

- 3 x LPUART / 2 x LPSPI / 2 x LPI2C / FlexIO

Analog

- 2 x 12b ADC, 1MSPS
- 2 x ACMP
- 1 x 8b DAC

Timers

- 1 x 8ch FTM (PWM)
- 2 x 4ch FTM (PWM/Quad Dec.)
- 1 x PDB
- 1 x 4ch LPIT / 1 x LPTMR / 1 x PWT
- 1 x RTC

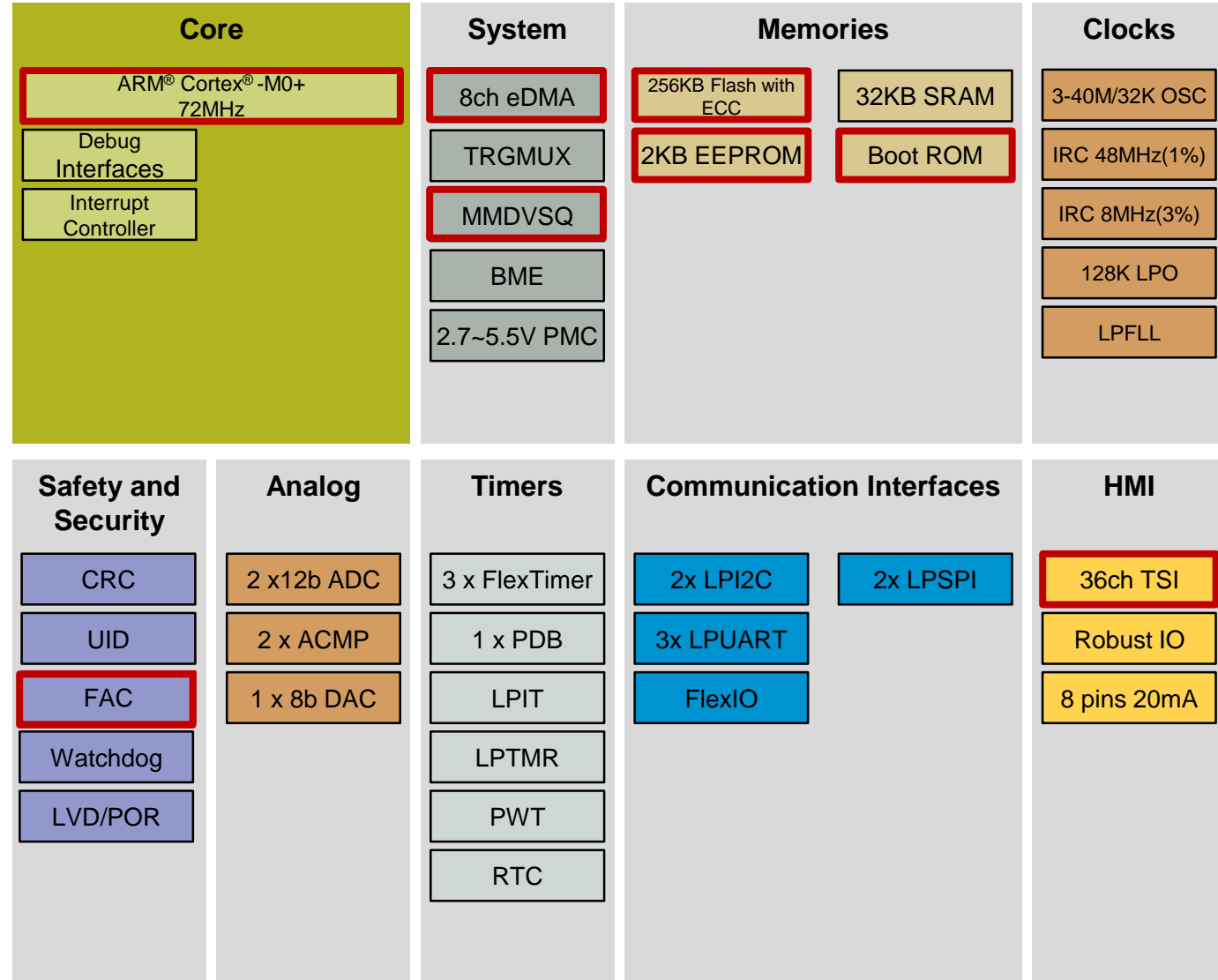
Others

- Up to 36ch TSI
- Up to 89 GPIO with glitch filter
- 2.7-5.5V, -40 to 105°C

Packages

- 100LQFP(0.5mm pitch)
- 64LQFP(0.5mm pitch)

Pin compatible within KE



KE1xF Master Block Diagram

Key Features:

Core/System

- ARM® Cortex® -M4F up to 168MHz
- 16ch eDMA
- TRGMUX
- MPU

Memory

- up to 512KB Flash with ECC
- up to 64KB SRAM with ECC
- up to 64K FlexMemory / 4KB EEPROM
- 8KB I/D Cache
- Boot ROM

Communications

- 2 x FlexCAN
- 3 x LPUART / 2 x LPSPI / 2 x LPI2C / FlexIO

Analog

- 3 x 12b ADC, 1MSPS
- 3 x ACMP
- 1 x 12b DAC

Timers

- 2 x 8ch FTM (PWM)
- 2 x 8ch FTM (PWM/Quad Dec.)
- 3 x PDB
- 1 x 4ch LPIT / 1 x LPTMR / 1 x PWT
- 1 x RTC

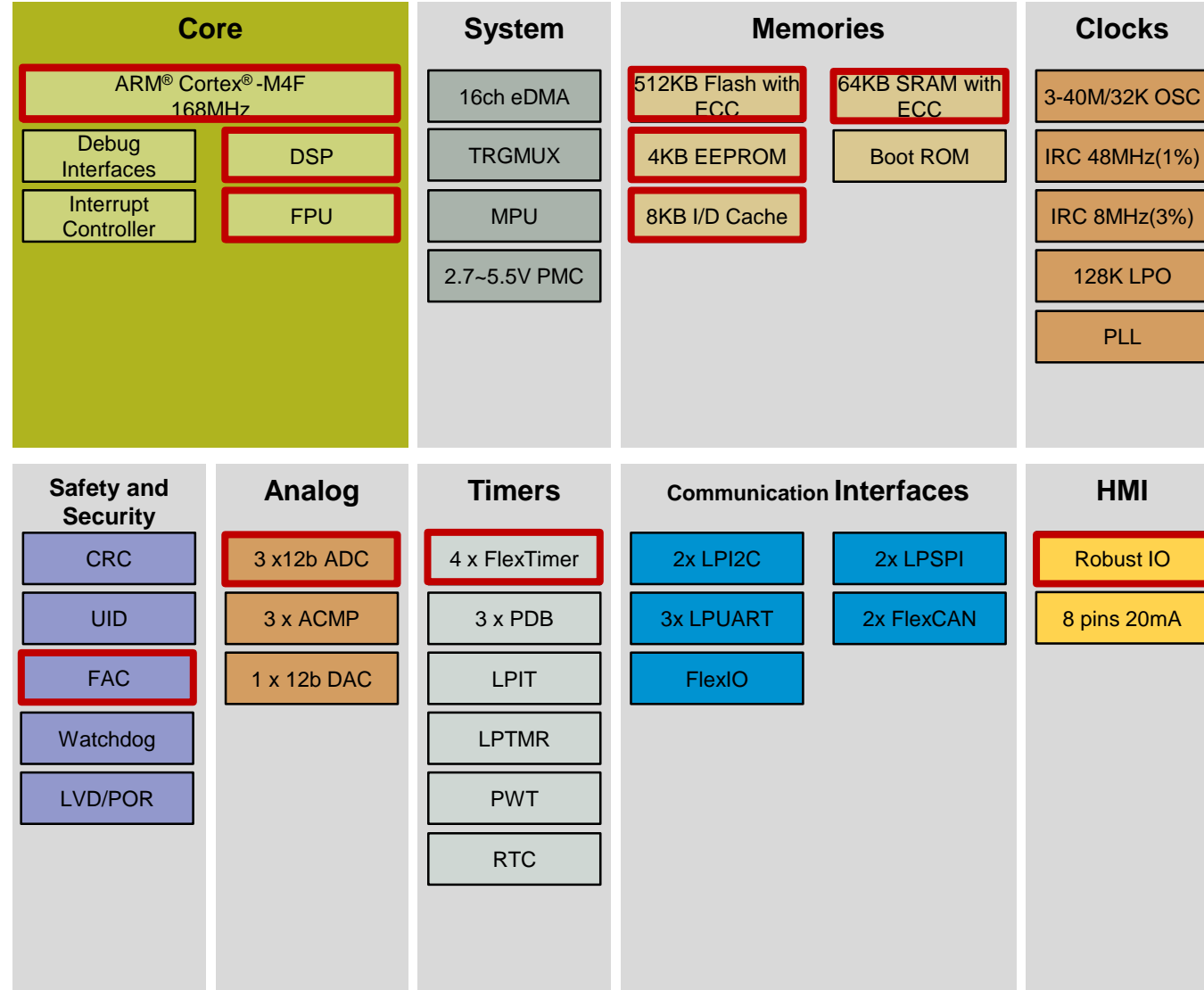
Others

- Up to 89 GPIO with glitch filter
- 2.7-5.5V, -40 to 105oC

Packages:

- 100LQFP(0.5mm pitch)
- 64LQFP(0.5mm pitch)

Pin compatible within KE



KE1X KEY FEATURES

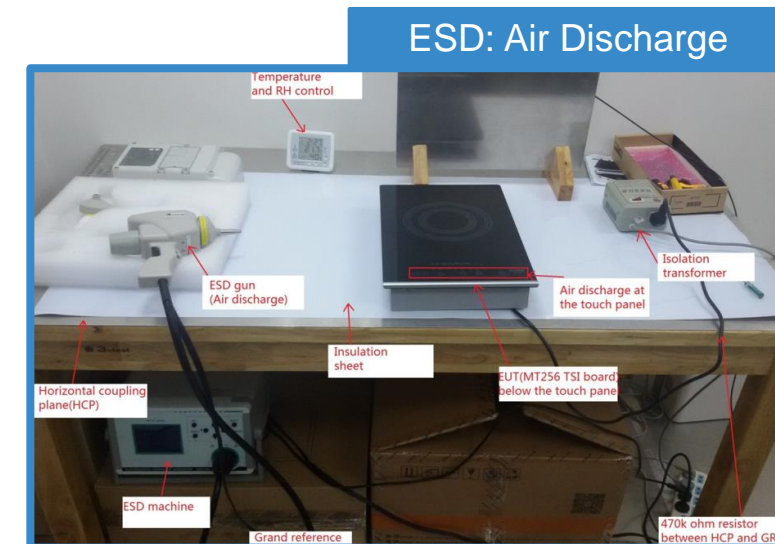
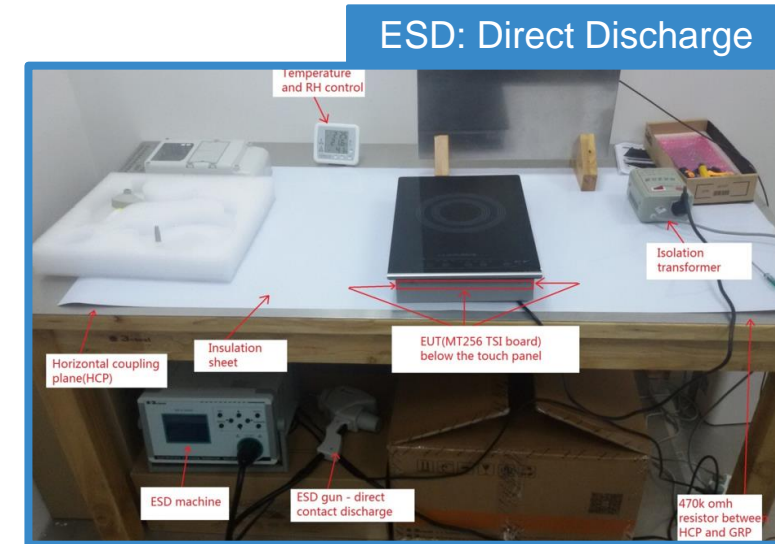
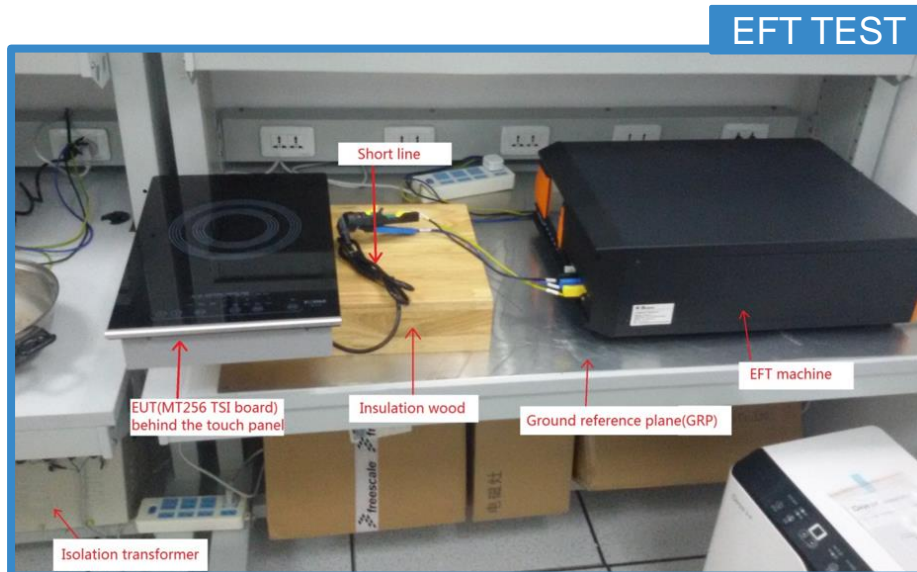


Key Features – Robust & Safety

Feature	Benefit	Feature Details
Robust	Better EMC performance and system robust in the harness environment and easy for PCB layout	Improved 5V I/O pad with digital filter, 5V operation provides better noise immunity
Safety Library IEC60730	Help manufacturers meet the IEC 60730 class B regulation	IEC60730 Class B Safety S/W routines certified by VDE/UL
Error-Correcting Code (ECC)	Automatically correct single-bit errors when reading from a memory location corrupted with a single-bit error.	Supports ECC on Flash and SRAM Memories, auto correction of one-bit error and reporting more than one-bit error.
Cyclic Redundancy Check (CRC)	Makes data robust against bit errors, meets IEC60730 standard	Contains one cyclic redundancy check (CRC) module which can generate 16/32-bit CRC code for data validation.
On-chip WDOG	Monitors the flow and execution of embedded software within a MCU.	Internal WDOG with independent clock source for system safety
External Watchdog Monitor (EWM)	Provides a backup mechanism to the internal watchdog that resets the MCU's CPU and peripherals.	The EWM differs from the internal watchdog in that it does not reset the MCU's CPU and peripherals. The EWM provides an independent EWM out signal that when asserted resets or places an external circuit into a safe mode.
Clock Loss Monitor	Monitors external oscillator failure.	On-chip clock monitor with reset and interrupt request capability.

Robust & Safety - KE1xZ EMC Performance

- Part number: KE15ZZ256VLL7
- DUT: IH Stove based on KE15Z TSI
- Test Result
 - IEC 61000-4-2(ESD)
 - Direct Contact Discharge: Passed +/- 12KV
 - Air Discharge: Passed +/- 15KV
 - IEC 61000-4-4(EFT): Passed +/- 4.4KV



Robust & Safety - IEC60730 Safety Standard for Household Appliances

IEC 60730

- **IEC60730 safety standard**

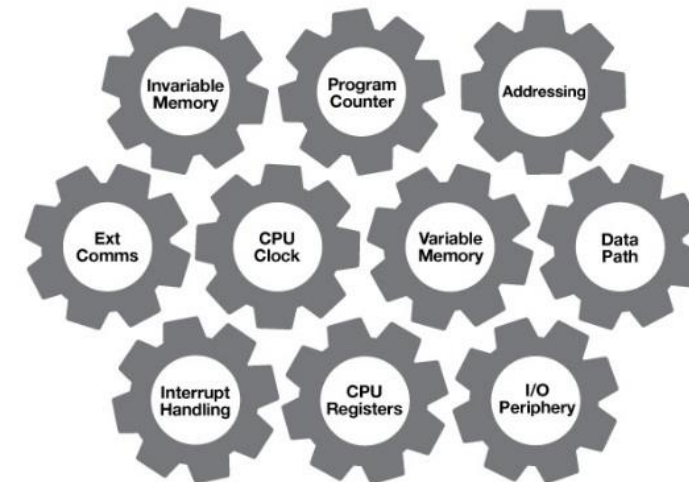
- Class B: to prevent unsafe operation of the controlled equipment

- **Features**

- Independent clocked Watchdog Timer - this provides a safety mechanism to monitor:
 - The flow of the software
 - Interrupt handling & execution
 - CPU clock (too fast, too slow and no clock)
- CRC Engine - this provides a fast mechanism for:
 - Testing the Flash memory
 - Check on serial communication protocols (UARTS, I2C, SPI)

- **Support**

- IEC60730 safety library is available on NXP website
- AN4873: IEC 60730B Safety Routines for Kinetis MCUs



VDE Prüf- und
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Unternehmensname (Name of the company) - Name of the company

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TSZECHIE



Offenbach, 2014-09-1

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Radim Vlnika

Your letter:
2014-09-18

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Translation: In any case the German version shall prevail
PRÜFBERICHT
zur Information des Auftraggebers
Test Report for the information of the applicant

NOTICE OF COMPLETION
AND
AUTHORIZATION TO APPLY THE UL MARK



09/02/2014

Freeseale Semiconductor Inc.
Mr. Michael Norman
6501 William Cannon Drive West
Austin, TX 78738 USA

Our Reference: File E471231, Vol. 1, Sec. 1 Project Number: 4786557746
Your Reference: S28/14
Project Scope: IEC 60730 Class B Safety Routines for Kinetis MCUs

Dear Mr. Michael Norman:
Congratulations! UL's investigation of your product(s) has been completed under the above Reference Number and the product was determined to comply with the applicable requirements. This letter serves as authorization to apply the UL Mark.

Records covering the product are now being prepared and will be sent in the near future. Until then, this letter authorizes application of the UL Mark for 90 days from the date indicated above.

Additional requirements related to your responsibilities as the Applicant can be found in the document "Applicant responsibilities related to Early Authorizations" that can be found at the following web-site:
<http://www.ul.com/EARlyAuthorizations>

Any information and documentation provided to you involving UL Mark services are provided on behalf of UL LLC (UL) or any authorized licensee of UL.

We are excited you are now able to apply the UL Mark to your products and appreciate your business. Feel free to contact me or any of our Customer Service representatives if you have any questions.

Very truly yours,

Jason Smith
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Reviewed by:

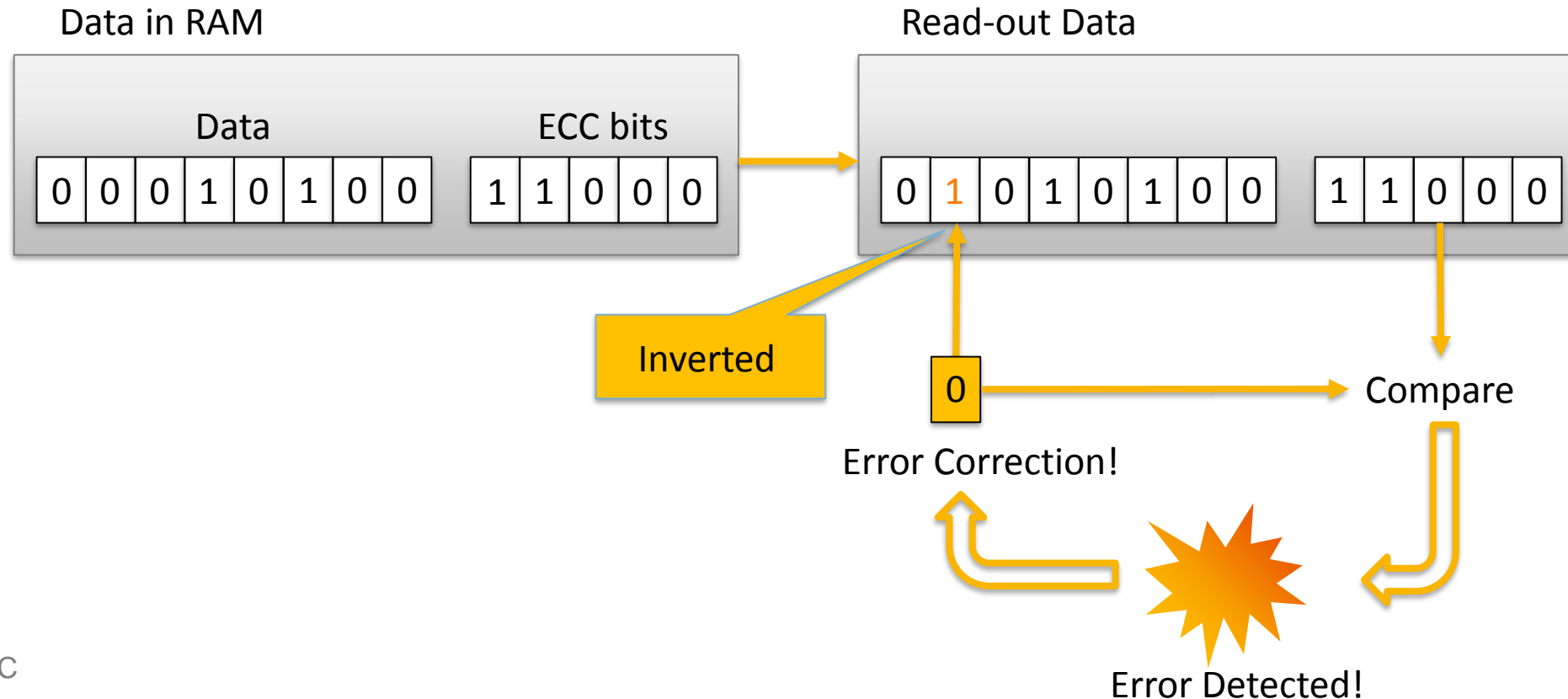
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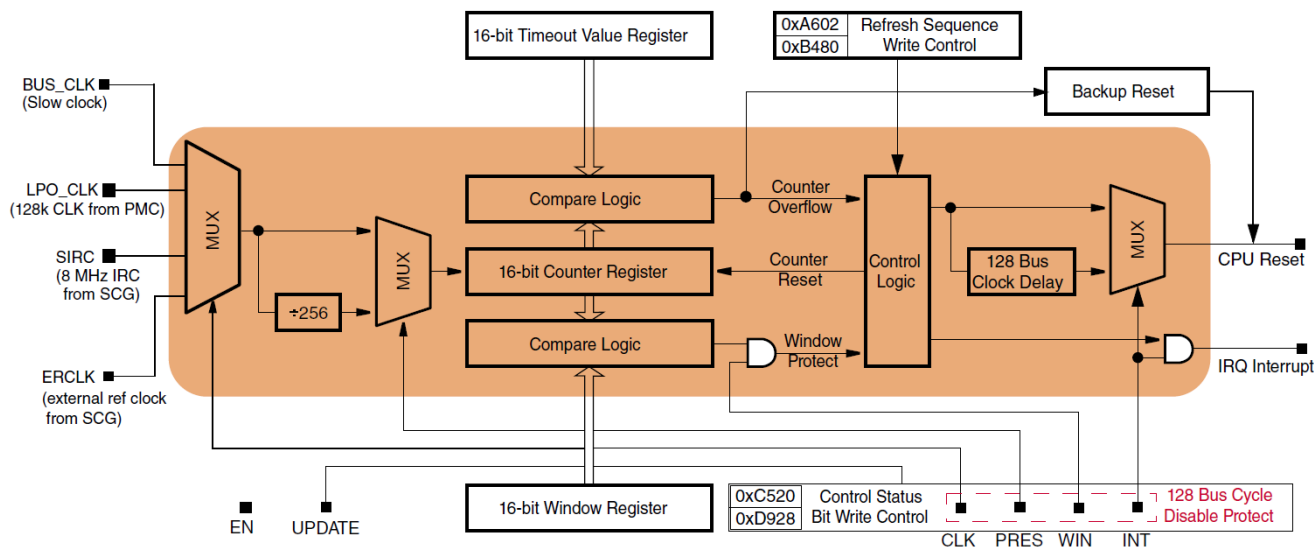
Robust & Safety - Error Correcting Code (ECC)

- **Both RAM and Flash support error correction check!**
- **RAM:** 8bit data with 5bits ECC, detect & correct up to 1 bit error, detect out up to 2 bits error, support ECC bits self error check
- **Flash:** 64bit data with 8bits ECC, detect & correct up to 1 bit error, support ECC bits self error check

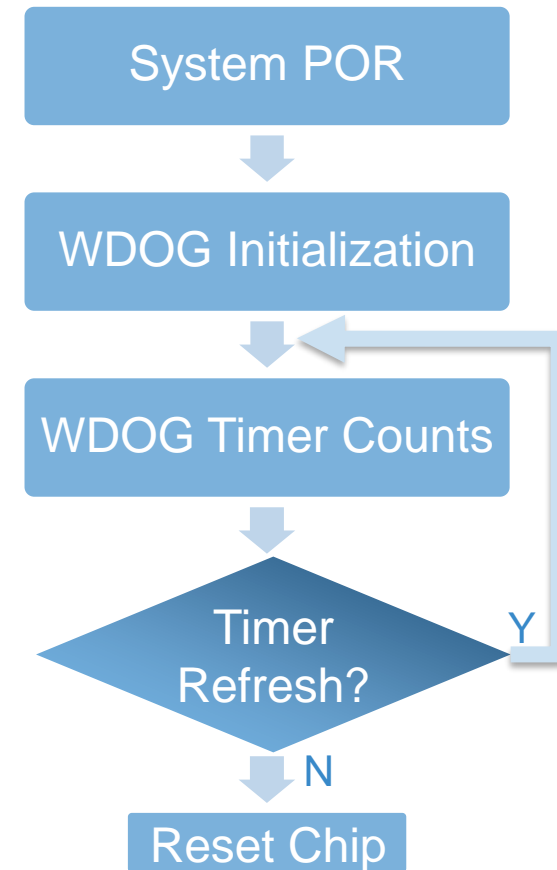


Robust & Safety - Watch Dog (WDOG)

- **Ensure software is executing as planned and CPU is not stuck in an infinite loop or executing unintended code.**
- **We also have External Watchdog Monitor (EWM) for monitoring external circuit.**



WDOG Block Diagram



WDOG Flow Chart



Key Features – Security & Safety

Feature	Benefit	Feature Details
Memory Protection Unit (MPU)	System monitoring of program execution to ensure that firmware is being executed from the expected memory range. Allows sandboxing, running software with restricted access permissions.	The MPU concurrently monitors bus transactions and evaluates their appropriateness using pre-programmed region descriptors that define memory spaces and their access rights
Flash Access Control (FAC)	Protection of software IP	Non-volatile control registers to set access privileges of on chip flash resources. Supervisor or execute only access can be set for up to 64 different segments
Flash Security Byte	Protection from firmware theft and application cloning	<ul style="list-style-type: none">• Ability to prevent debug access to the processor• Ability to set a 64-bit backdoor key to regain debug access
Unique ID	Software can be used to uniquely identify the MCU as a trusted device	On-chip 128-bit unique identification number which is programmed in factory and unique for each device

Security – Flash Access Control (FAC)

- Flash access control (FAC): configurable memory protection scheme designed to allow end users to utilize software libraries while offering programmable restrictions to these libraries
- For KE18F512, FAC has x_XACCH/L registers and each has 32 bit, so, there are $32 * 2 = 64$ bits, so the segment count is also 64. As the total flash size is 512K bytes, then the size of each segment is $256K \text{ bytes} / 64 = 8K \text{ bytes}$.
- NOTE: Program ONCE!** After a segment is marked as execute-only, there is no way to put it back to code and data access.

The following figure shows how the bit is mapped to the segment number.

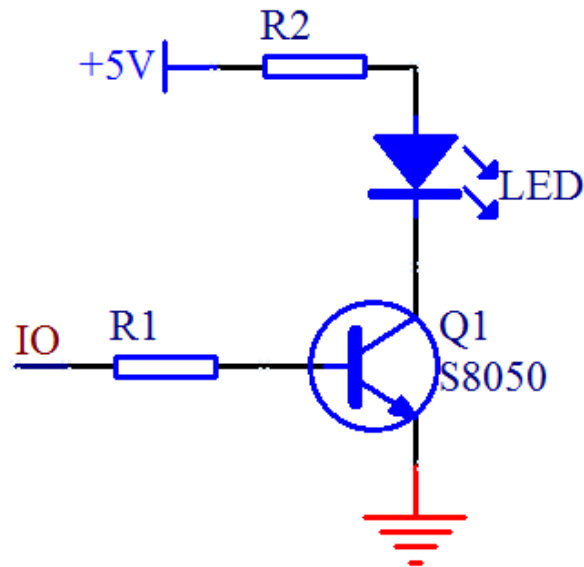
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Key Features – Comprehensive Peripherals

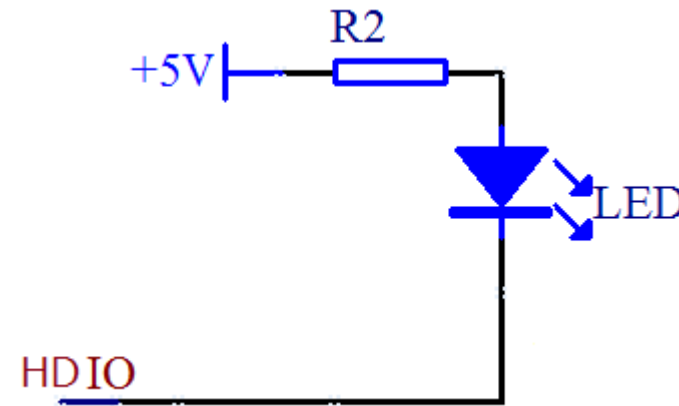
Feature	Benefit	Feature Details
Touch Sensing Interface (TSI)	Provides capacitive touch sensing detection with enhanced EMC robustness.	Robust TSI supports both mutual cap mode and self cap mode, providing flexibility for up to 25 touch sensing channels for self-capacitance mode, 36 channels for mutual capacitance mode.
FlexTimer (FTM)	<ul style="list-style-type: none"> Supports 2x 3-phase motor control with dead time insertion and 1x PFC control with more PWM channels Supports up to 32 PWM channels 	Supports input capture, output compare, quadrature decoder and the generation of PWM signals to control electric motor and power management applications. The FTM time reference is a 16-bit counter that can be used as an unsigned or signed counter. Optimized for motor control with sync to ADC via PDB
ADC	1MSPS 12b ADC with up to 16ch input per module, provides fast sampling rate for prompt data conversion and storage	Contains two 12-bit SAR ADC modules. The ADC module supports hardware triggers from FTM, LPTMR, PIT, RTC, external trigger pin and CMP output.
CMP	Provide over-current, over-voltage protection as well as zero-crossing detection for full voltage range.	Two analog comparators, each has its own independent 8-bit DAC, and supports up to 6 analog inputs from external pins
Smart Peripherals (LPUART, LPSPI, LPI2C, FlexIO)	Power efficiency	Support working in low power modes, avoid frequently waking CPU and further reduce power consumption
Enhanced robust IOs	More control signal Input/Output More flexible hardware design Save BOM cost	<ul style="list-style-type: none"> Up to 89 GPIOs on 100LQFP, 58 GPIOs on 64LQFP Enhanced robust IOs make sure the high performance under noisy environment 8x High Drive IO: offer maximum 20mA driver current each GPIO interrupt with Glitch filter Single cycle fast GPIO
Trigger MUX Control (TRGMUX)	Provide very flexible module-to-module interconnections	An extremely flexible methodology for connecting various trigger sources to multiple pins/peripherals. Allows software to configure the trigger inputs for various peripherals.
High Accuracy Internal Fast/Slow Oscillator	Save BOM cost	Save on board crystal oscillators. A 8MHz crystal costs ~\$0.5

Comprehensive Peripherals – Enhanced robust IOs

- 8 high drive pins offer maximum 20mA driver current each
- High drive function configurable on each pins by SW
- Driving external LEDs/components without external driving circuit, which **save BOM cost** and board size



Normal IO driving a LED



HD IO driving a LED

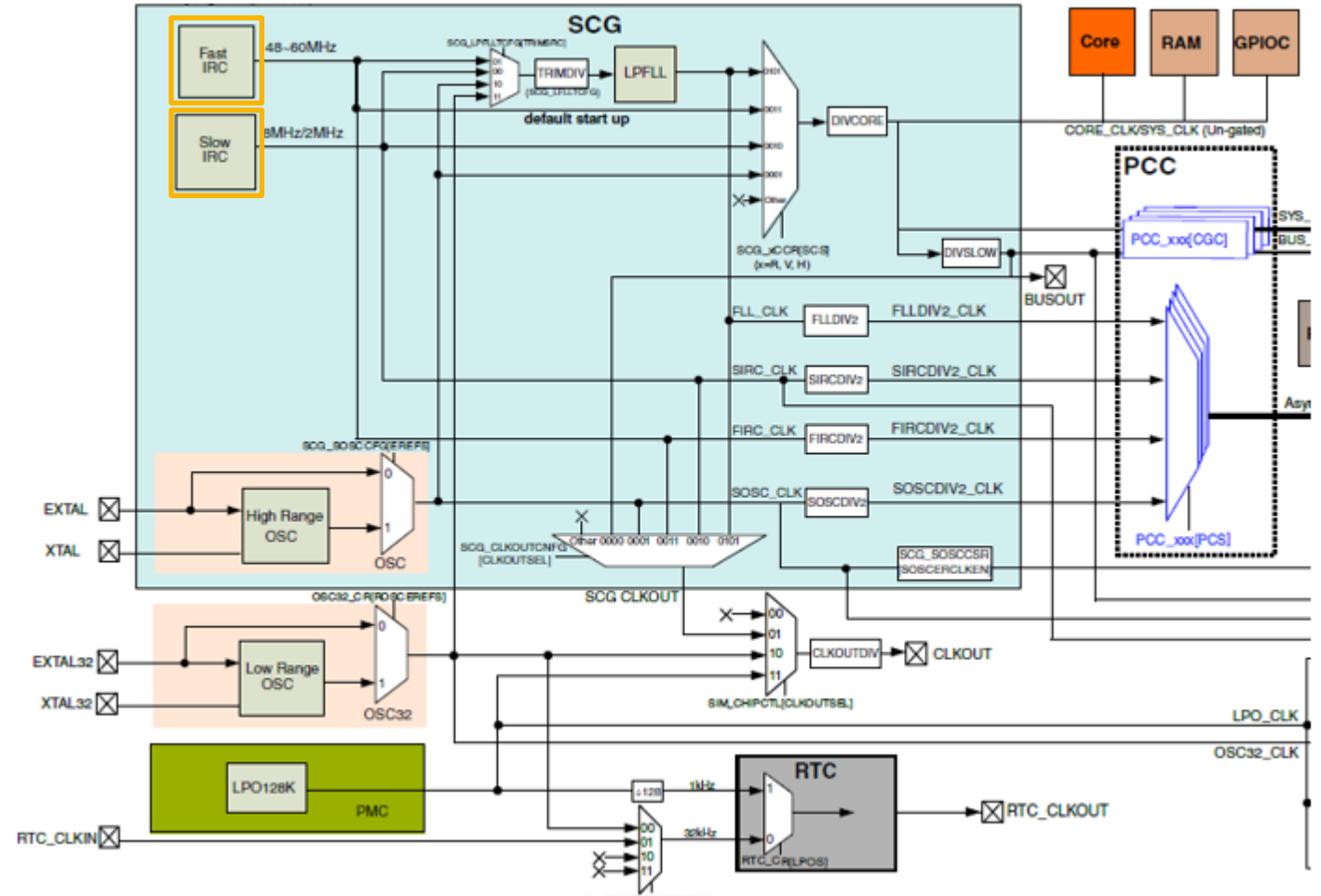
Comprehensive Peripherals – High Accuracy Internal Fast/Slow Oscillator

- **On chip:**

- FIRC: 48MHz-60MHz, **<1%** max deviation across full temperature
- SIRC: 8MHz/2MHz, **3% max** deviation across full temperature

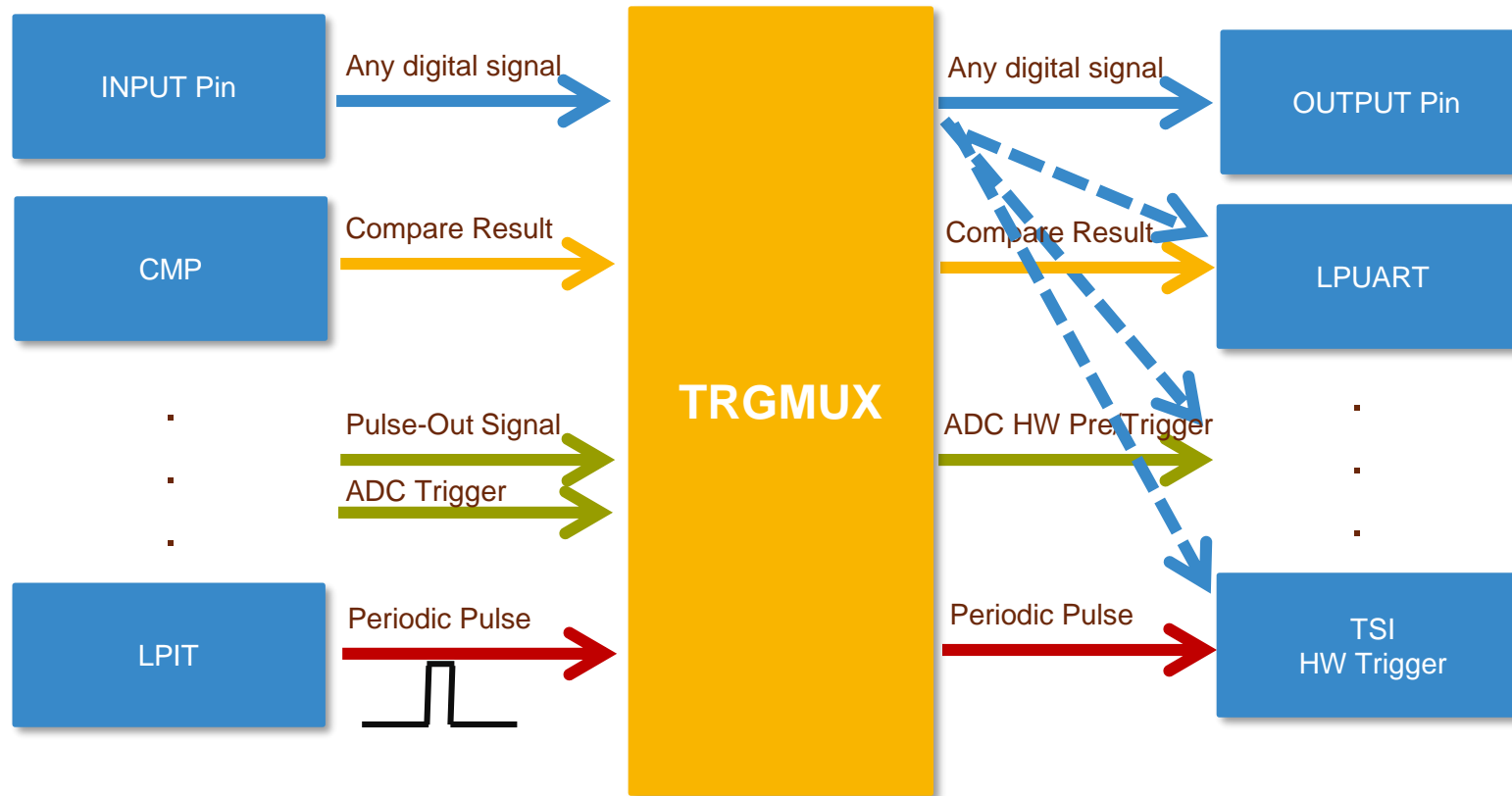
- **Benefit:**

- Save external crystal, board size and BOM cost
- SIRC can be used by peripherals in low-power mode with **lower power consumption**



Comprehensive Peripherals - TRGMUX

- Flexible trigger scheme for Module Interconnectivity



Comprehensive Peripherals - Smart Peripherals



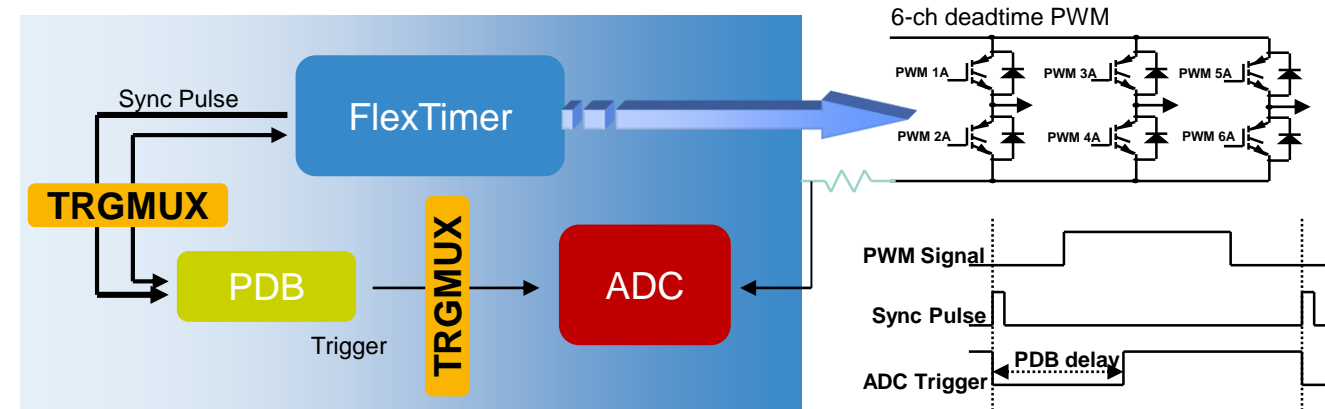
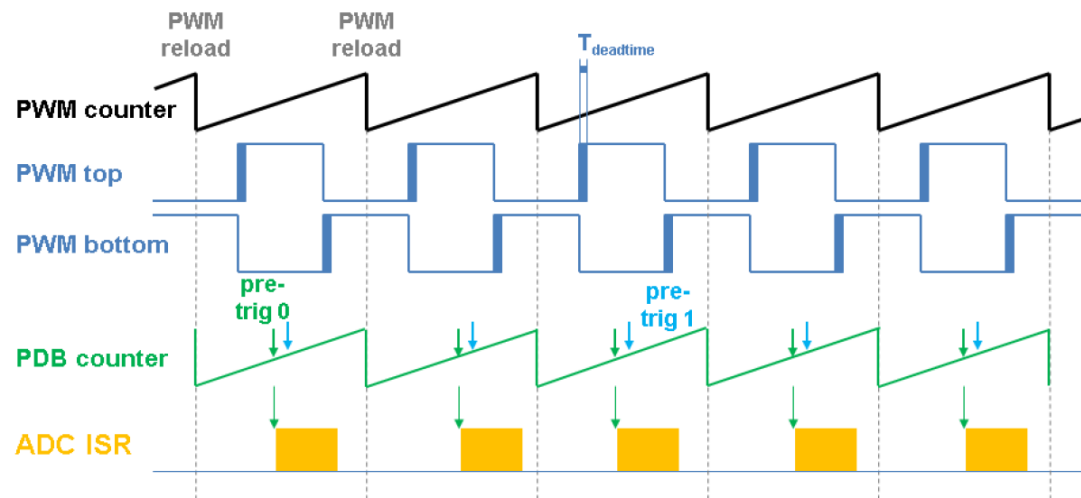
- **Smart peripherals support working in low power modes, avoid frequently waking up CPU and further reduce power consumption.**

Peripheral	Low Power Functionality
eDMA	Allows smart peripherals to trigger asynchronous DMA request in STOP/VLPS modes to perform DMA transfer and return to current power mode with no CPU intervention
LPUART	Functional in Stop/VLPS modes provided the clock it is using remains enabled. Supports asynchronous transmit and receive operations to the bus clock supporting communication down to STOP/VLPS modes.
LPSPi	Functional in Stop/VLPS modes provided the clock it is using remains enabled. Supports slave mode address match wake-up function and first message capture down to STOP/VLPS modes
LPI2C	Functional in Stop/VLPS modes provided the clock it is using remains enabled. Supports multiple address match wake-up function down to STOP/VLPS modes
ADC	Functional in Stop/VLPS modes provided the clock it is using remains enabled.
FLEXIO	Functional in Stop/VLPS modes provided the clock it is using remains enabled.

Comprehensive Peripherals – FTM/ADC/PDB/TRGMUX

Use Case - BLDC Motor Control:

- The KE1xZ uses a 6-channel FlexTimer (FTM) to generate a 6-channel PWM, and two 12-bit SAR ADCs to measure the back-EMF voltage, DC-bus current, and DC-bus voltage. The FTM and ADC are synchronized via the Programmable Delay Block (PDB). One channel from another independent FTM is used for the slow-loop interrupt generation.



Peripheral settings:

- The top signal (PWM counter) shows the FTM counter reloads. The dead time is emphasized at the **PWM top** and **PWM bottom** signals. The FTM_TRIG is generated on the PWM reload, which triggers the PDB (resets the PDB counter).
- The PDB generates the first pre-trigger for the first ADC sample with a delay of approximately $T^{PWM} / 2$. This delay ensures a correct DC-bus current sampling.
- When the conversion of the first ADC sample is completed, the ADC ISR is entered and the fast-loop control function is calculated.
- The PDB uses the back-to-back mode to automatically generate the pre-trig 1 (for the next quantity measurement) immediately after the first conversion is completed.

TOUCH SENSING INTRODUCTION

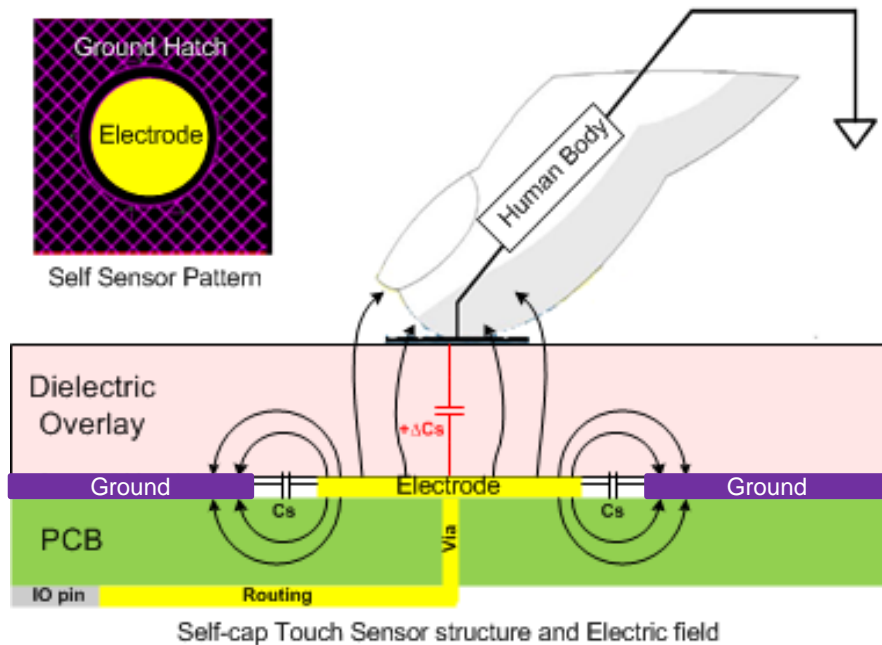
Touch Sensing Applications in Home Appliance



New TSI on KE15Z

What Customers Want	CAN We Meet?	New TSI in KE15Z
More keys	✓	Robust TSI supports both mutual cap mode and self cap mode, providing flexibility for up to 25 touch sensing channels.
More robustness	✓	Advance EMC Robustness, Passed IEC61000-4-6 3V/10V level test
High Sensitivity	✓	Adjustable in resolution and sensitivity
Waterproof	✓	Supports shield electrode, which can minimize the water impact.
Less workload for MCU	✓	New architecture for TSI, high performance, no need for MCU's interactive with eDMA support
Easy to develop in system	✓	NT NXP Touch Library Support
One chip solution for low BOM cost	✓	Only 1 or 2 pins are need for the electrode, no external components

TSI Modes - Self-Capacitance Touch Sensing



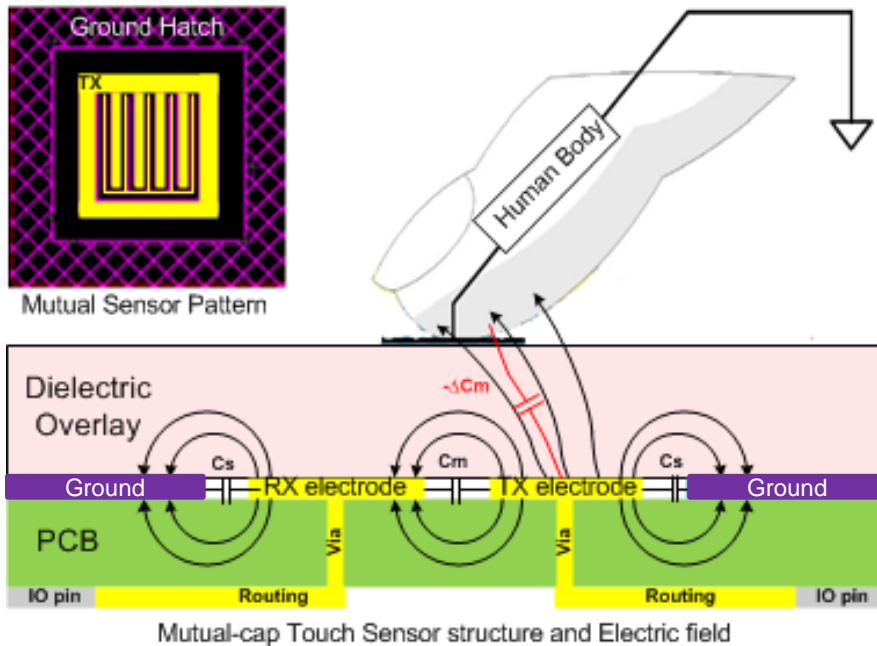
Sensor Structure

- **C_s** : Intrinsic self cap. Comes from parasitic. 10pF~50pF as usual.
- **ΔC_s** : Touch increased self cap. 0.3pF~2pF as usual.
- **Sensitivity of sensor**: $\Delta C_s/C_s$. 1%~10% as usual.
It depends on: electrode pattern, thickness/dielectric of overlay and PCB routing.

Property

- Simple and mature electrode pattern design
- Least crosstalk among sensing channels
- Single point sensing: buttons, sliders, wheels.

TSI Modes - Mutual Capacitance Touch Sensing



Sensor Structure

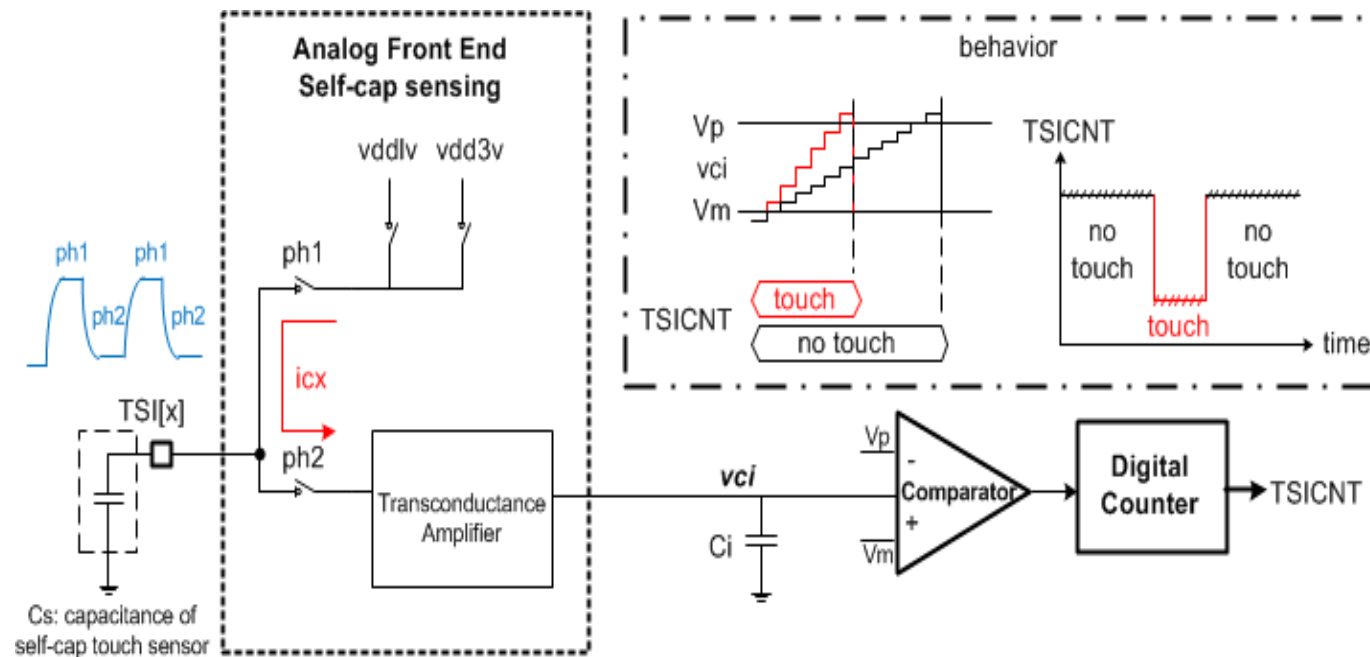
- **C_m**: Intrinsic mutual cap. Decided by electrode pattern. 2pF~10pF as usual.
 - **ΔC_m**: Touch reduced mutual cap. 0.3pF~2pF as usual.
 - **C_s**: Parasitic self cap. 10pF~50pF as usual.
 - **Sensitivity of sensor**: ΔC_m/C_m. 1%~20% as usual.
- It depends on: electrode pattern & thickness/dielectric of overlay.

Property

- Intrinsic good sensitivity and moisture immunity
- Good pin utilization by matrix floor-plan.
- Easier pin routing.
- Single point sensing and Multipoint sensing.

TSI Measurement

- TSI IP provides adjustable touch sensing sensitivity by using parasitic cancellation for both of self-cap and mutual-cap sensing mode to support sensing on thick overlay. (ex: over 5mm-10mm)



TSI Technical Support

- **Hardware Kit**

Freedom Platform

FRDM-KE15Z

- Ultra low -cost/power development platform
- Supports two self-cap buttons on board
- Compatible with Freedom touch shield FRDM-TOUCH



Freedom Shield

FRDM-TOUCH

- demo more touch patterns for promotion and customer evaluation.
- 4 mutual cap buttons, 1 touch slide and 1 touch rotary.



TSI Evaluation Board

X-RD-KE15Z-TSI

- Comprehensive touch patterns, including mutual cap buttons, self-cap touch spring keys and pads, shield electrode, touch slide/rotary.
- Internal evaluation board



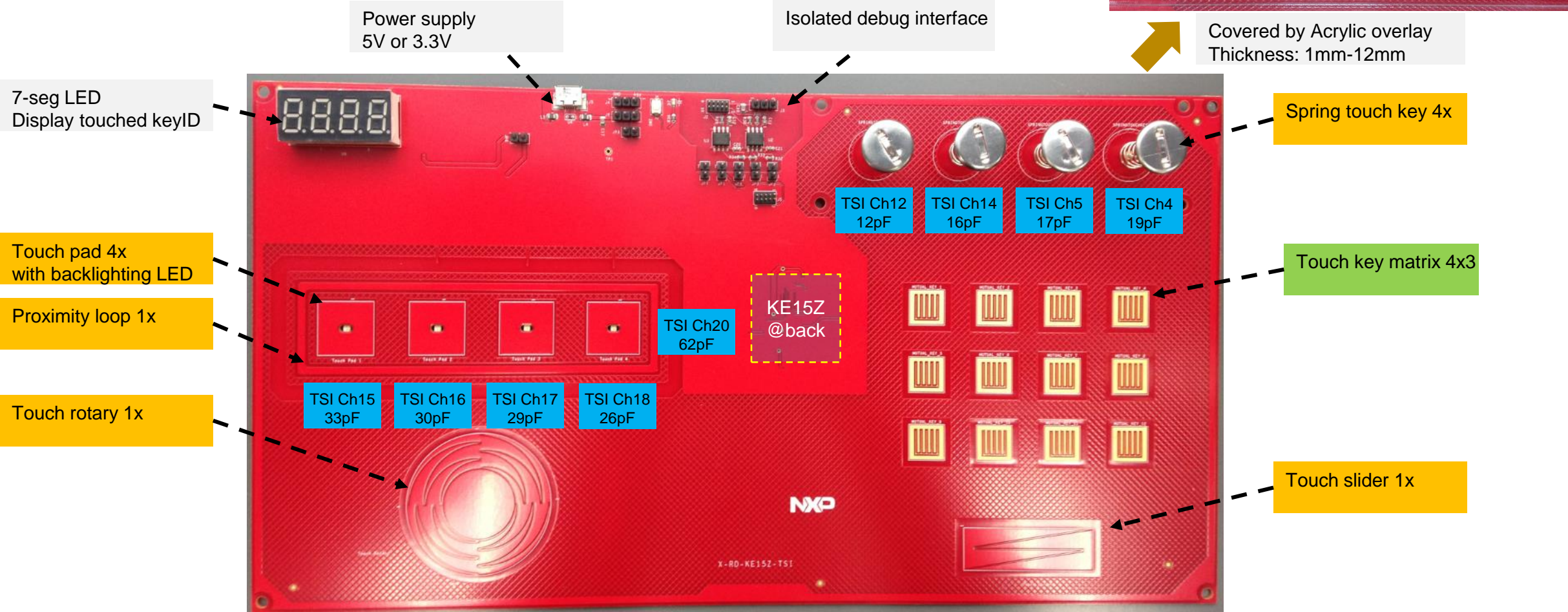
- **Software**

- NXP Touch Library NT 2.0, released with MCUXpresso as middleware
- TSI apps demo example code integrated in SDK 2.0

- **Document**

- User Guide: KE15Z TSI User Guide available on <http://www.nxp.com/doc/KE15ZTSIUG>
- Application Notes: AN5420 <KE15Z TSI Development for Low Power Applications>

KE15Z TSI Test - Test Board RD-KE15Z-TSI



KE15Z TSI Test Requests from Key Customer

Test No	Test Item	Test Case	Test Result
1	Basic Functional Test	Self Capacitance Mode Mutual Capacitance Mode IOT((Indium-Tin-Oxide) test	Supports both Self and Mutual Capacitance Mode. Replace the previous RO-based(Relaxation Oscillator) touch sensing method. Passed ITO(Indium-Tin-Oxide) test which is another pattern of touch electrode, based on a transparent film
2	Conversion Time Test	Measure the conversion time from start conversion to end-of-scan interrupt using LPTMR	Sample time: 1us (switching clock: 1.04MHz) Conversion time for 16-bit resolution: 100us
3	Sensitivity Boost Test	Test sensitivity using different key configurations	Supports configurable sensitivity to recognize touch across a variety of overlay thickness.
4	Proximity Test	One customer requests 3cm proximity distance over 3cm overlay.	The proximity distance can reach 35cm under ideal conditions: the proximity wire loop is 16cm in diagonal, shield feature enabled, and sensitivity boost mode enabled.
5	Liquid Tolerance Test	Test impacts of liquid across different liquid material and drop size: water, salt water, detergent, juice, coco-cola, soy sauce, rapeseed oil.	No impact of small drop size, touch works well and no false touch. The shield electrode can help improve liquid tolerance very much, as a result, the TSI counter changes very little when water drops on the touch keys, where there's a shield electrode placed nearby the touch keys.
6	Cold Steam Test	One leading customer requests cold steam and heating test for 72 hours, no mis-trigger.	Passed this test, with 2-layer design, no guard rings, just one active shielding electrode. Achieve the best results, best sensitivity with the simplest layout and software
7	Metal Plate Test	The metal plate adds capacitance and results in increased TSI counter that is similar to the counter changes by finger touch	The metal plate causes TSI counter change, but no false touch because of the well tuned touch threshold configured by software, and touch works well with the coin placed on the overlay
8	Glove Operation Test	a touch device in a car should accommodate use with gloved hands. Increasing the touch sensitivity may cause unintentional triggers when the user is not wearing gloves.	TSI works well with different gloves and no false touch when the user is not wearing gloves. Meets the customer's requirement.
9	EMC Test IEC61000-4-6 Test	In home appliance productions, the IEC61000-4-6 performance is very critical, which is the system level standard to evaluate immunity to conducted disturbances.	The KE15Z TSI pass the IEC61000-4-6 both 3V/10V test, even passed 15V test in one leading customer. and even can run correct touch operation under 10V test, which is better than customer expect. The new touch sensing method on KE15Z have shown immunity to a wide range of noise.

KE15Z TSI Test - IEC61000-4-6 EMC

Customer Requirement:

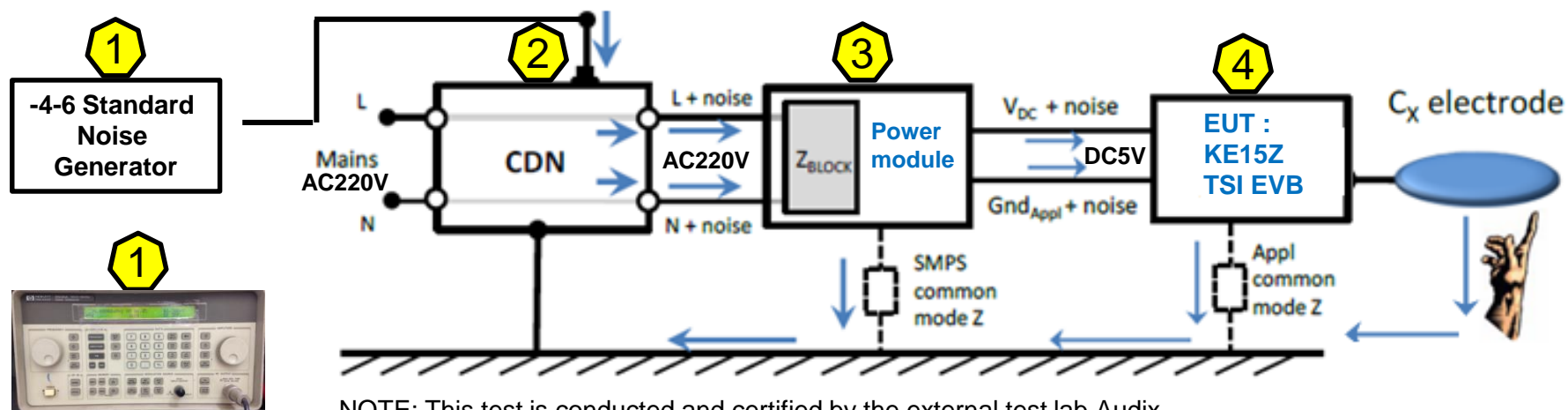
In home appliance productions, the IEC61000-4-6 performance is very critical, which is the system level standard to evaluate immunity to conducted disturbances. In general, customers require MCU based touch products pass IEC61000-4-6 3V test with correct touch operation, and 10V test(stronger noise injection) with no mis-trigger when there's no touch operation.

Test Result: **PASS**

The test result shows the KE15Z TSI pass the IEC61000-4-6 both 3V/10V test, and even can run correct touch operation under 10V test, which is better than customer expect.

- 3V, 150K-230MHz, no mis-trigger and correct touch operation
- 10V, 150K-80MHz, no mis-trigger and correct touch operation

Leading customer passed 15V test!

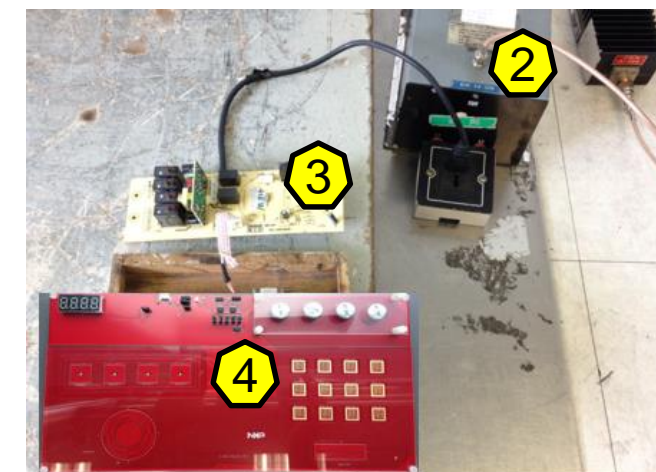


1. Applicant: NXP Semiconductor (China) Limited Shanghai Branch Office
2. Description of Device:

EUT	M/N
KE15Z touch control panel	RD-KE15Z-TSI (KE15Z256VLL7)
3. Date of Measurement: Aug 26, 2016
4. Test Item:
Injected Currents Susceptibility: EN 55024:2010 (IEC 61000-4-6:2010)
5. Measurement Results: Pass
6. Test Data:
See the additional test data.
All the test set-up set under the requirement of the customer.
7. Test Photos:
See the additional test photos.

Vincent Gao
(Vincent Gao / Test Engineer)

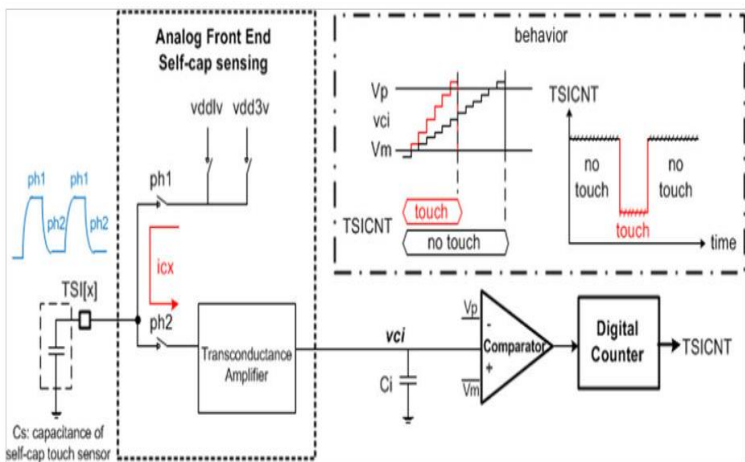
Wenqiang Yang
Authorized Signatory
(Wenqiang Yang / Deputy Assistant Manager)



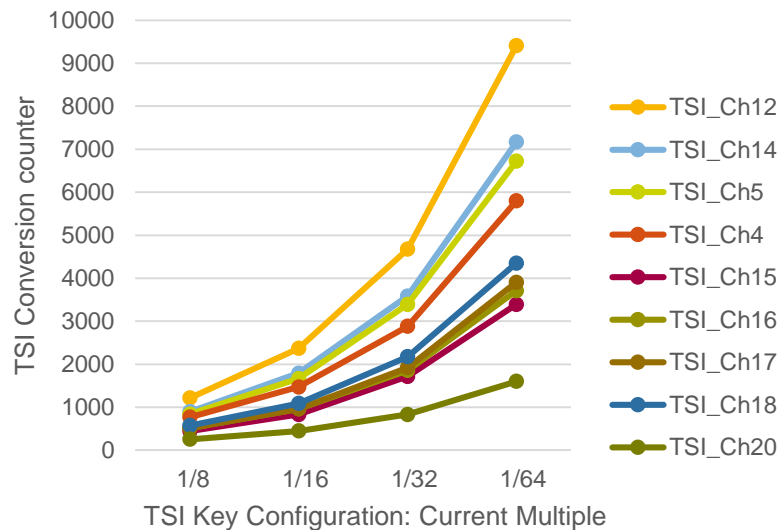
TSI Basic Functional Test – Self-Capacitance Mode

TSI Conversion Result				Used to configure scan rate							configure digital filter			charge/discharge current					calculated	
TSI Channel	Counter			Clock Generation							Multi Scan Per Channel		Comparator			Current Amplifier			Intrinsic Capacitance Calculated Cx	Sensitivity Calculated %
	Untouched	Touched	Delta	Main Clock (MHz)	Prescale	SSC	SSC High Width	SSC High Random Width	SSC Low Width	Switching Clock (MHz)	Decimation	Order	Ci	Vp-Vm	Vdd3v	S_XIN	S_XCH	Current Amplifier (S_XIN*S_XCH)		
TSI_Ch12	1216	1088	128	16.65	16	OFF	0	0	0	1.04	8	2	90	1	3.3	1/4	1/2	1/8	11	11
	2368	2112	256	16.65	16	OFF	0	0	0	1.04	8	2	90	1	3.3	1/4	1/4	1/16	12	11
	4675	4160	515	16.65	16	OFF	0	0	0	1.04	8	2	90	1	3.3	1/4	1/8	1/32	12	11
	9408	8260	1148	16.65	16	OFF	0	0	0	1.04	8	2	90	1	3.3	1/4	1/16	1/64	12	12

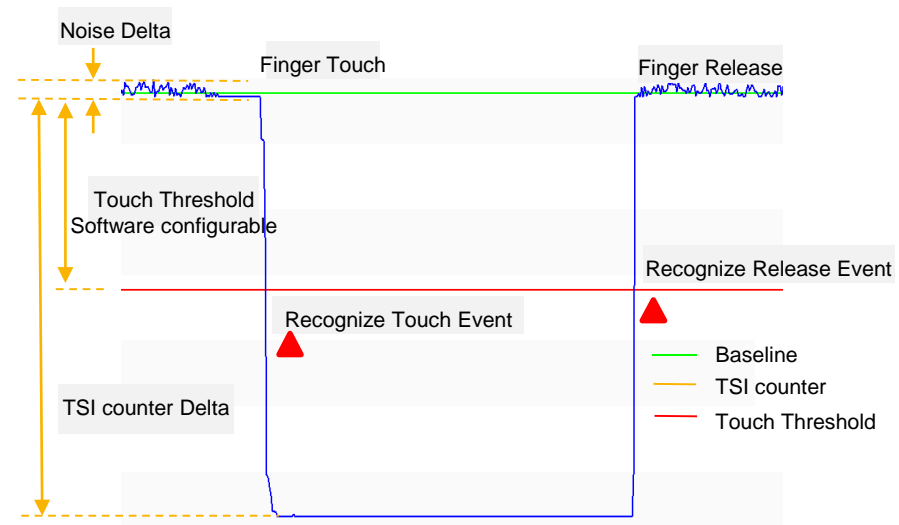
TSI Block Diagram – Self Mode



TSI counter / Configuration



TSI Conversion Result Process



Test Result:

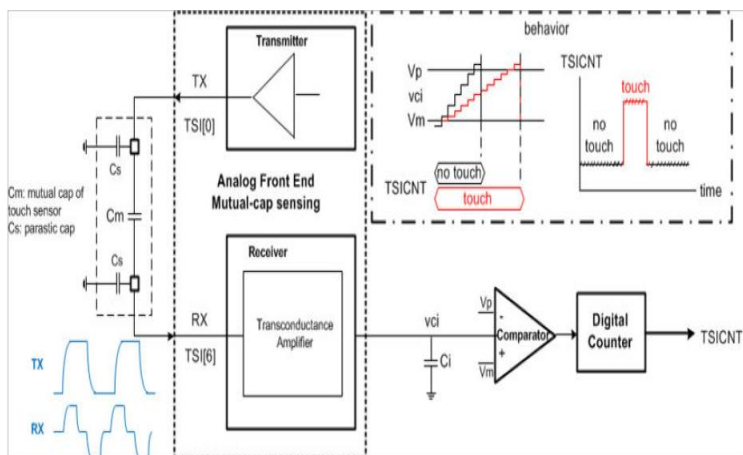
1. Self capacitance mode measures the capacitance on an electrode connected to a single TSI channel.
2. Convert the capacitance into a digital count by driving average current on the electrode and measuring the charge/discharge times.
3. Suit for the spring touch key, touch slider, rotary
4. The electrodes far from MCU have high TSI count value, which means high parasitic capacitance.

Sensitivity = (TSI counter Delta / Baseline)%
The large sensitivity value means the stronger signal caused by finger touch.
Sensitivity around 10% is recommended

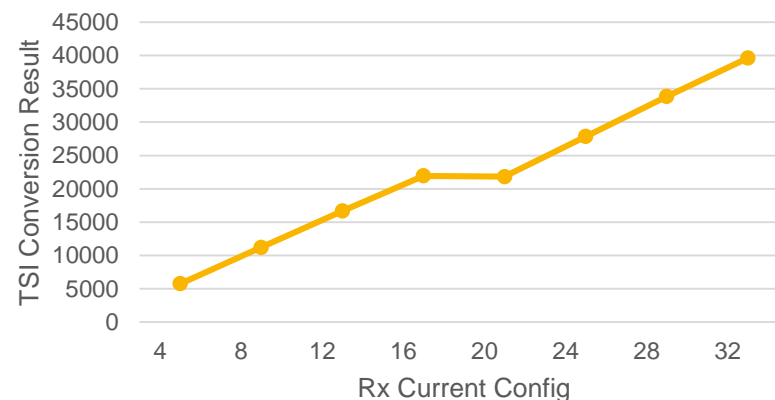
TSI Basic Functional Test - Mutual Capacitance Mode

TSI Conversion Result					Used to configure scan rate							configure digital filter				Rx current					Calculated		
TSI Channel		Counter			Clock Generation							Multiple Scan Per Channel		Comparator		Rx Current Parameters				Sensitivity Boost Current (uA)	ΔV (mV)	Sensitivity Calculated %	
Tx	Rx	Untouched	Touched	Delta	Main Clock (MHz)	Prescale	SSC	SSC High Width ChargeNumbr T3	SSC High Random Width	SSC Low Width	Switching Clock (MHz)	Decimation	Order	Ci	Vp-Vrr	Rs	M_PMIR RORL	M_PMIR RORR	Multiple Factor				
TSI_Ch1	TSI_Ch11	5765	5920	155	16.65	16	ON	6	6	3	1.33	8	2	90	1	10K	4	1	4	0	1	3	
		11200	11450	250	16.65	16	ON	6	6	3	1.33	8	2	90	1	10K	8	1	8	0	1	2	
		16650	17100	450	16.65	16	ON	6	6	3	1.33	8	2	90	1	10K	12	1	12	0	1	3	

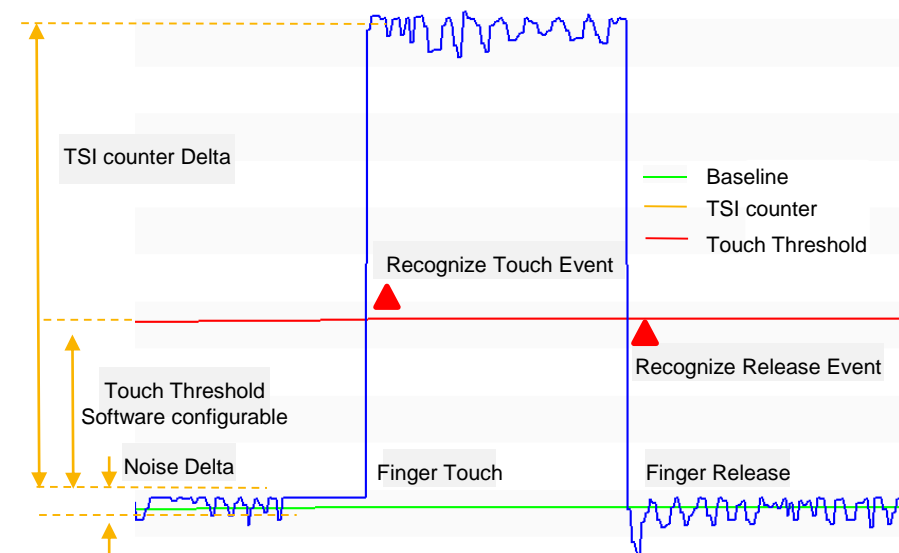
TSI Block Diagram – Mutual Mode



TSI Conversion Result(counter) / Key Configuration



TSI Conversion Result Process



Test Result:

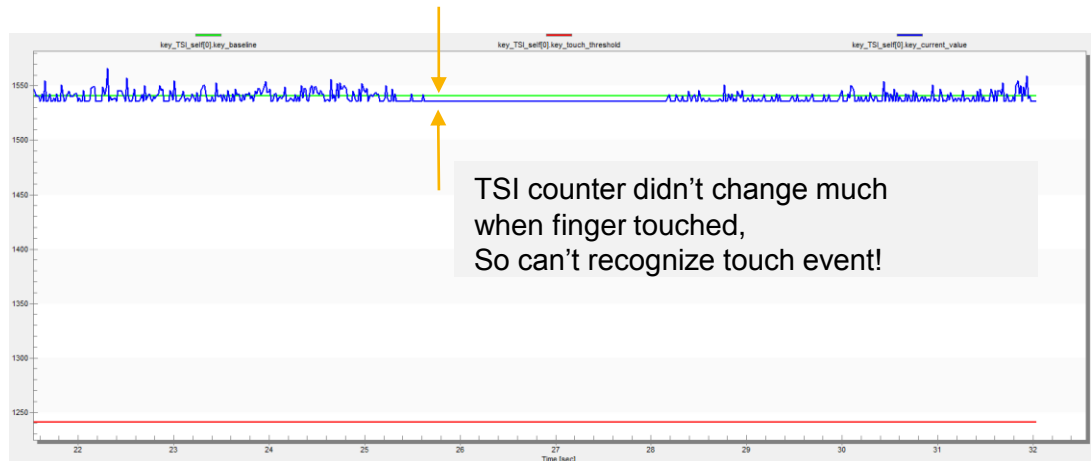
1. Mutual capacitance mode measures the capacitance between 2 electrodes connected to TSI Tx(transmit) and Rx(receive) channel respectively.
2. Convert the capacitance into a digital count by measuring the amount of charge received on the Rx channel.
3. Suit for the touch pad matrix(6x6)

Touch:
TSI counter Delta > Touch Threshold
Release:
TSI counter Delta < Touch Threshold

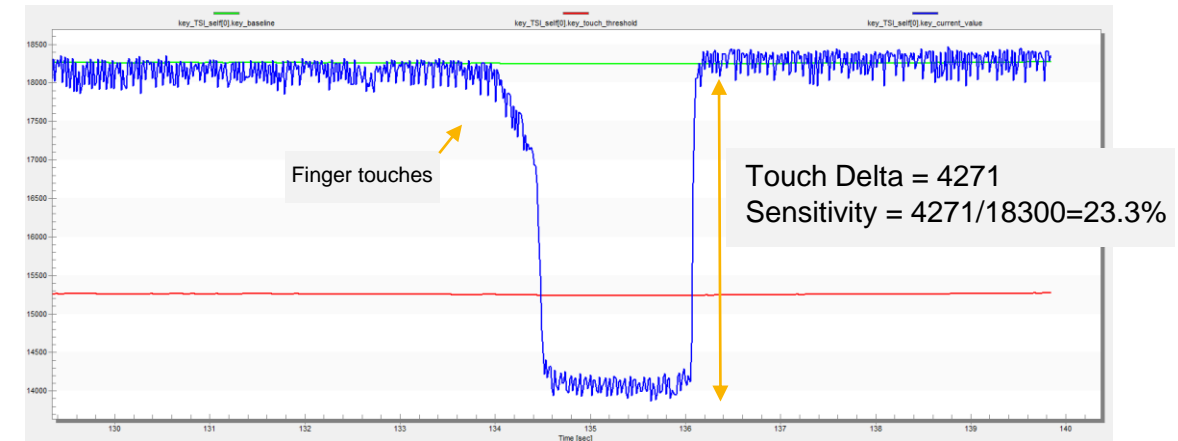
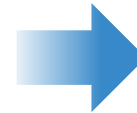
KE15Z TSI Test - Sensitivity Boost

TEST RESULT:

1. When the touch overlay is very thick (like 12mm Acrylic), it becomes very hard to detect a touch event correctly, because of the poor sensitivity caused by the huge parasitic capacitance.
2. Enabling Sensitivity Boost feature can increase sensitivity by removing part parasitic capacitance virtually.
3. Touch works well under the 12mm thick overlay with sensitivity boost enabled



Disabled Sensitivity Boost



Enabled Sensitivity Boost

KE15Z TSI Test - Liquid Tolerance: Cold Steam Test

Customer Requirement:

Hot applications like hobs and ovens. When the user opens the door then hot steam will come out and due to the fact that the surface of the HMI and touch keys are colder than the steam it will condense immediately at these areas.

Test Result:

1. Water spray to simulate the very small water droplet due to condense.
2. Pass. The impact of the small water droplet can be ignored, no mis-trigger and touch operation works well under the water spray.

Water Sprays on the touch pad



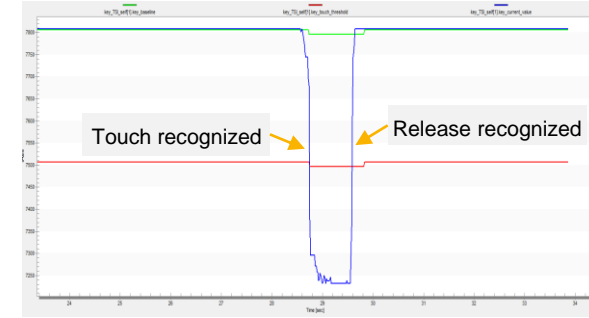
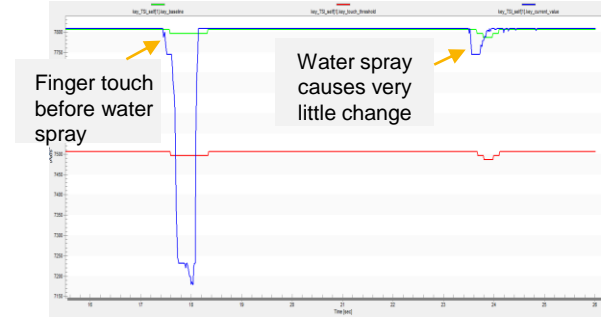
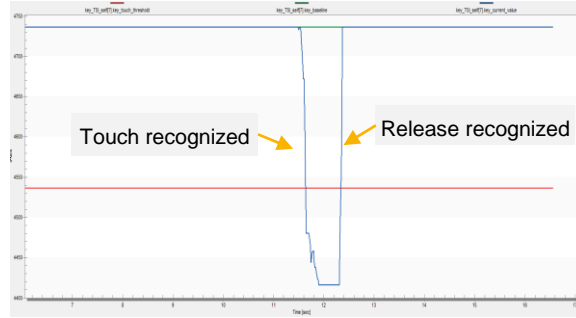
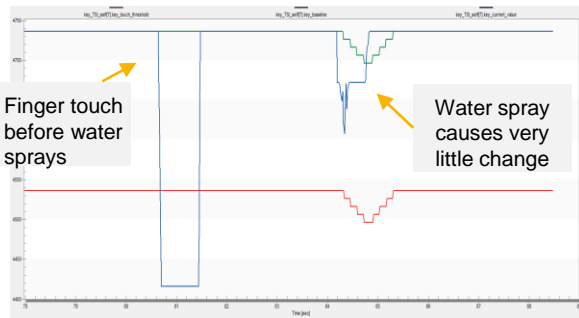
Touch works under small water droplets



Water Sprays on the spring key

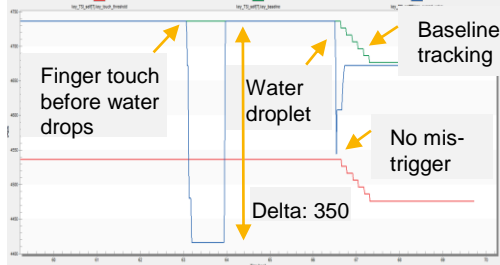


Touch works under small water droplets

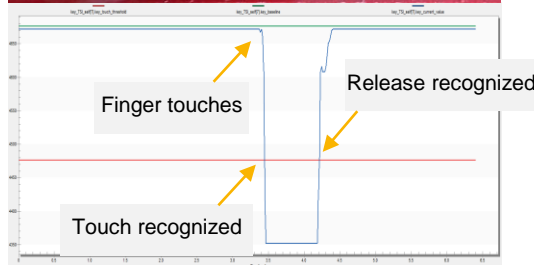
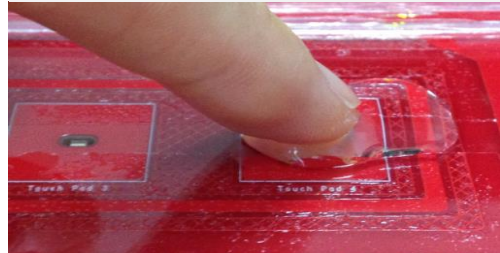


KE15Z TSI Test - Liquid Tolerance Test: Water Droplets

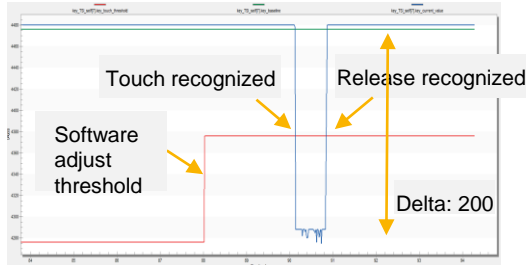
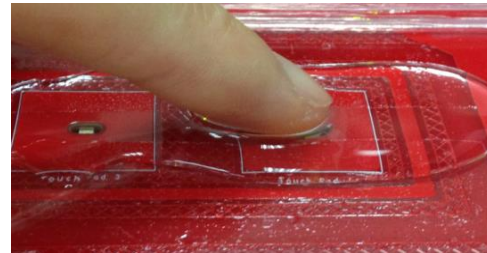
Water drops on the touch pad key



Touch works with large water droplet



Touch works under water film *

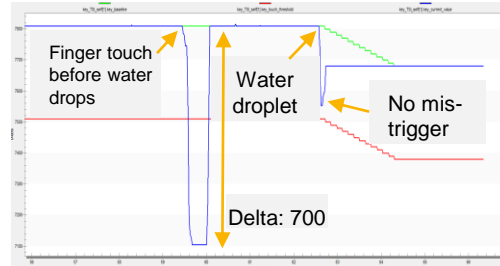


Test Result:

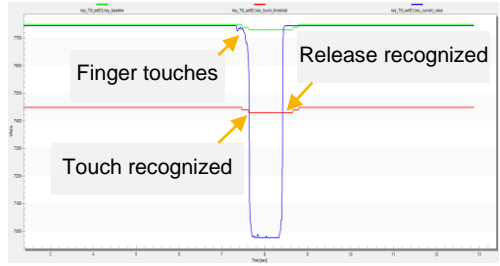
1. The KE15Z TSI targets in home appliance applications which require robust operations with liquid droplets/film.
2. The test result shows that the large water droplet adds capacitance and results in decreased TSI counter that is about 2/3 for the touch pad and about 1/3 of the counter changed by finger touch for the spring key.
3. The water film(i.e. big size droplet covering 2 keys) changes the TSI counter a lot, sometimes can cause mis-trigger.
4. The water film decreases the touch sensitivity, for the touch pad, touch works with condition, only when the touch threshold is decreased by software to handle the low sensitivity, but touch can work well under the water film for the spring key.

*NOTE: Need software supports threshold adjust.

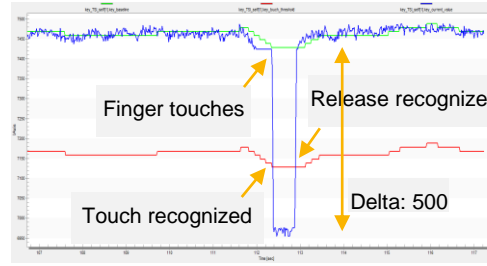
Water drops on the spring key



Touch works with large water droplet

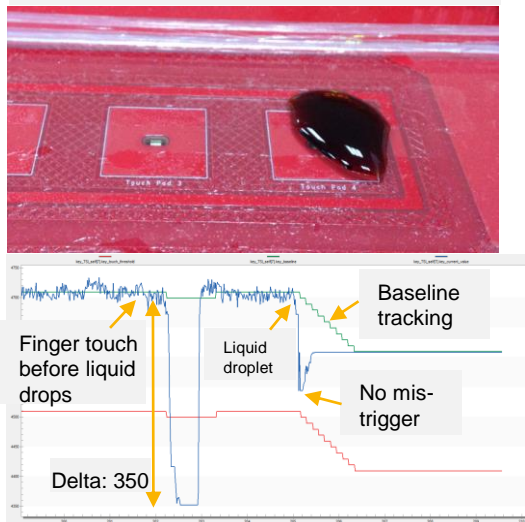


Touch works under water film

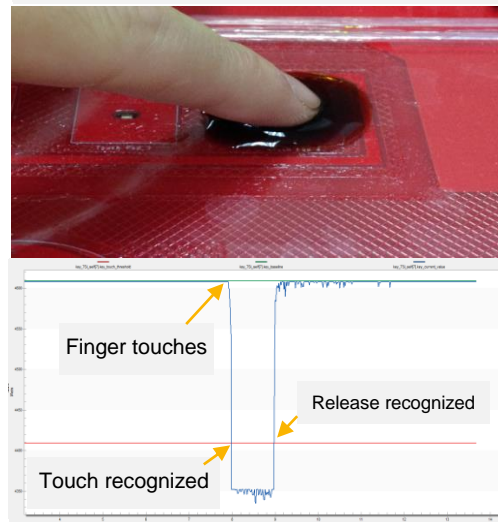


KE15Z TSI Test - Liquid Tolerance: Soy Sauce Test

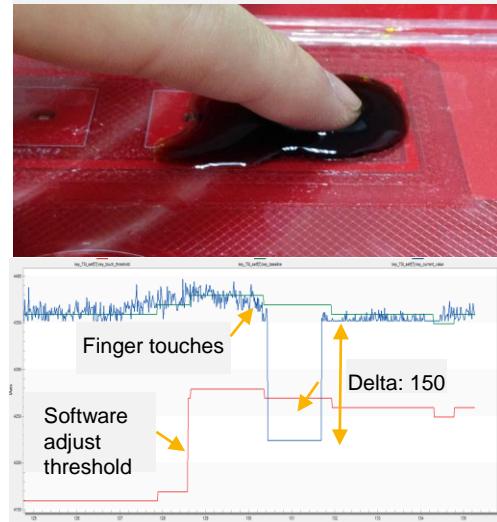
Soy sauce drops on the spring key



Touch works with soy sauce droplet



Touch works under soy sauce film *

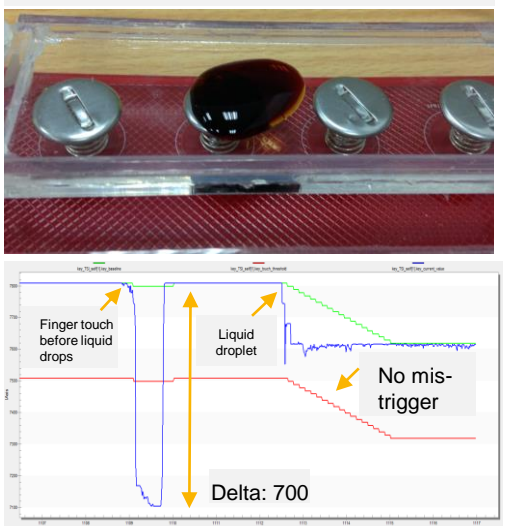


Test Result:

1. The soy sauce droplet causes TSI counter change, about 1/2 of the counter changed by finger touch for the touch pad.
2. No mis-trigger caused by the soy sauce droplet because the touch threshold is tuned as big enough by software.
3. The soy sauce film(i.e. big size droplet covering 2 keys) changes the TSI counter a lot, sometimes can cause mis-trigger.
4. Touch works with condition under the soy sauce film for the touch pad, only when the touch threshold is decreased by software to handle the low sensitivity.

*NOTE: Need software supports threshold adjust.

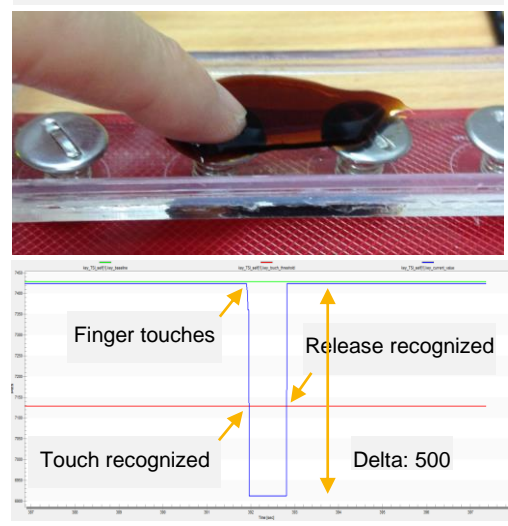
Soy sauce drops on the spring key



Touch works with soy sauce droplet



Touch works under soy sauce film



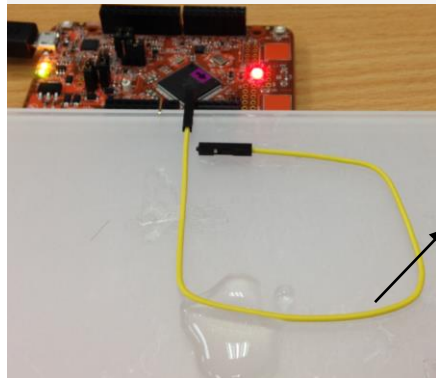
Test Result:

1. The soy sauce droplet causes TSI counter change, about 1/3 of the counter changed by finger touch for the spring key.
2. No mis-trigger caused by the soy sauce droplet because the touch threshold is tuned as big enough by software.
3. The soy sauce film(i.e. big size droplet covering 2 keys) changes the TSI counter a lot, sometimes can cause mis-trigger.
4. Touch can work well under the soy sauce film for the spring key.

KE15Z TSI Test - Liquid Tolerance: Shield Electrode

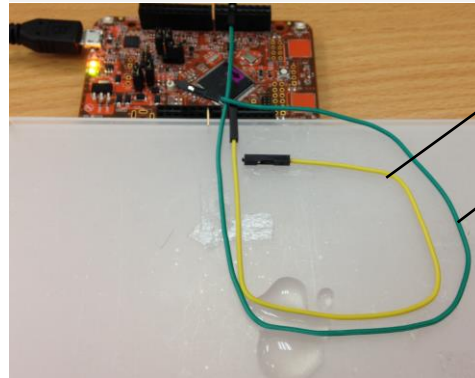
- The shield electrode can help improve liquid tolerance very much, as a result, the TSI counter changes very little when water drops on the touch keys, where there's a shield electrode placed nearby the touch keys.

Water drops on the touch electrode



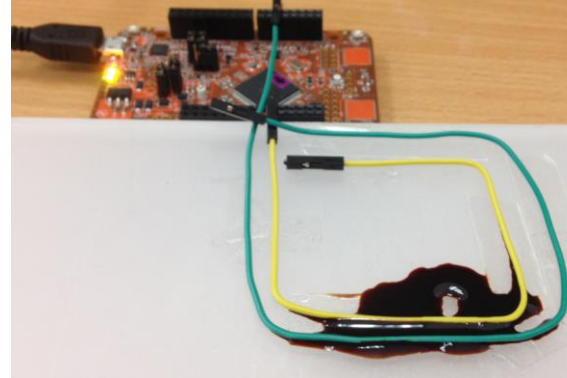
Touch electrode

Water drops on the touch and shield electrodes

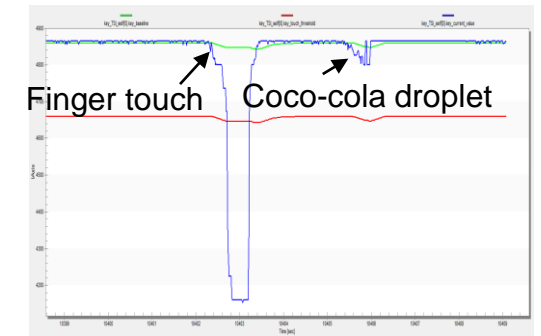
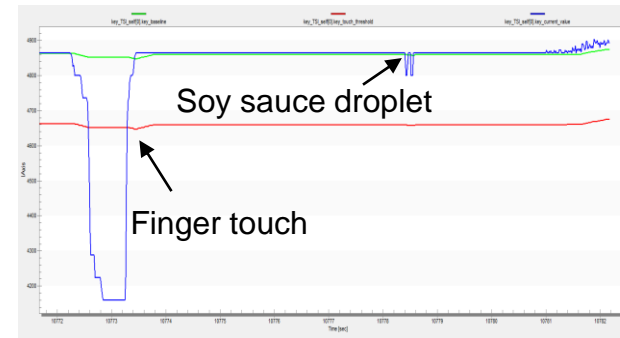
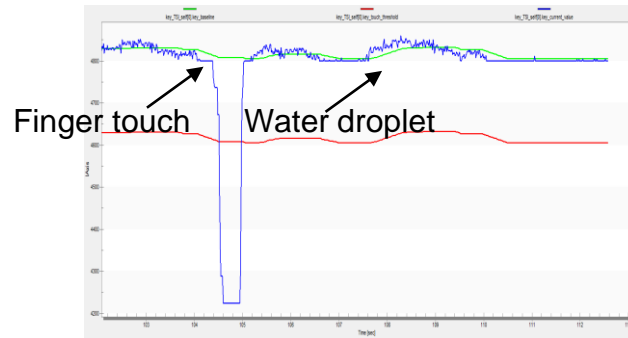
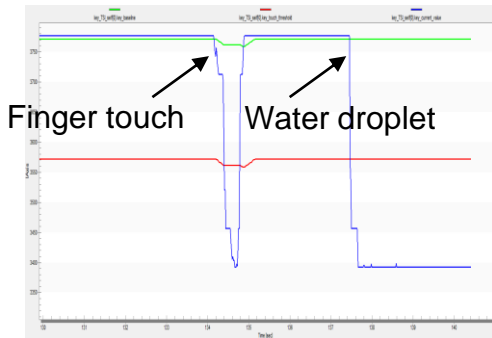
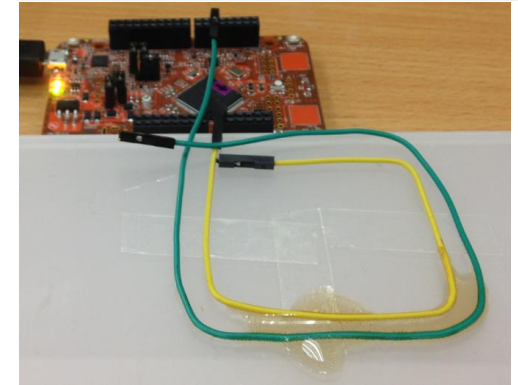


Touch electrode
Shield electrode

Soy sauce drops on the touch and shield electrodes

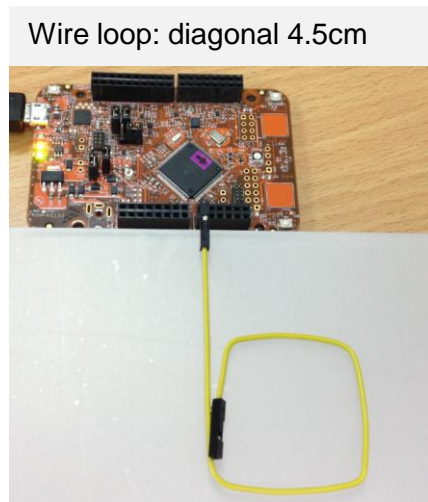


Coco-cola drops on the touch and shield electrodes



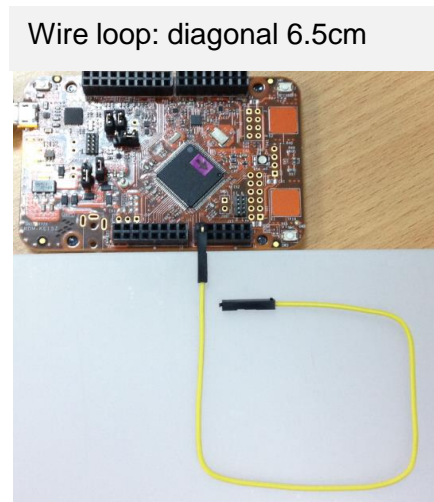
KE15Z TSI Test - Proximity

- The proximity distance is proportional to the sensor area, i.e. the diameter or diagonal of the proximity loop. The large proximity loop can help increase the proximity distance
- The proximity distance reaches 35cm, when the wire loop is 16cm in diagonal and the TSI is configured as sensitivity enabled with 12.5pF C_{removed} .



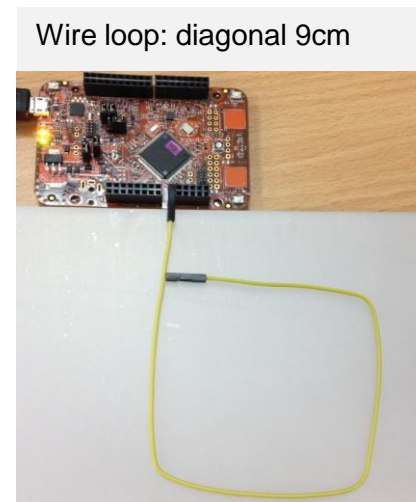
Sensitivity Boost Enable, C_{removed} : 7.5pF

Proximity:
13cm



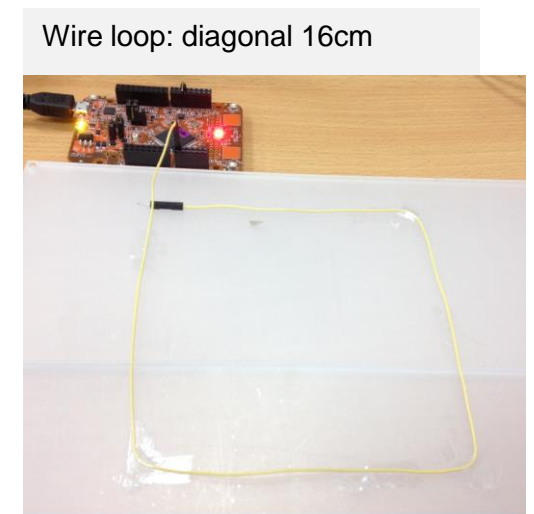
Sensitivity Boost Enable, C_{removed} : 7.5pF

Proximity:
15cm



Sensitivity Boost Enable, C_{removed} : 7.5pF

Proximity:
18cm



Sensitivity Boost Enable, C_{removed} : 12.5pF

Proximity:
35cm

KE15Z TSI Test - Glove Operation

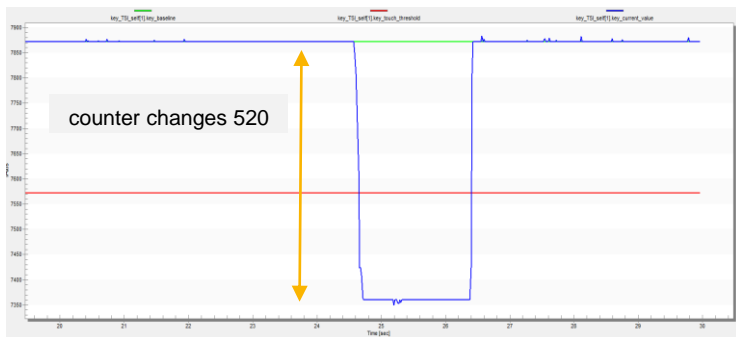
Customer Requirement:

In medical applications, a touch application should accommodate use with surgical gloves. Similarly, a touch device in a car should accommodate use with gloved hands. Increasing the touch controller's sensitivity may cause unintentional triggers when the user is not wearing gloves.

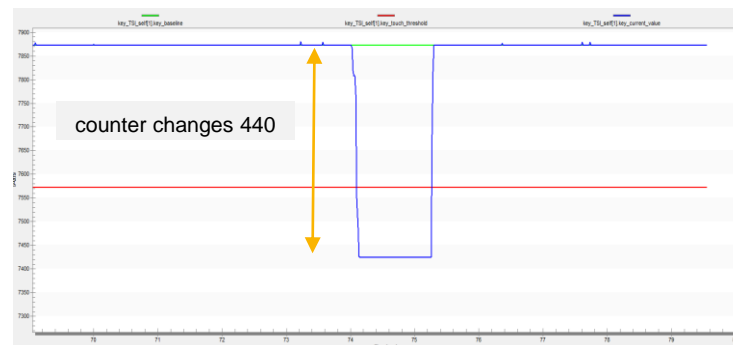
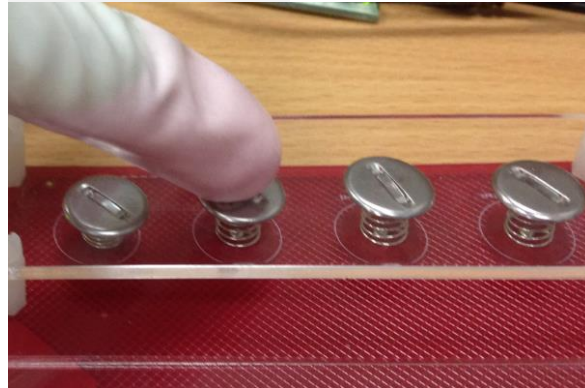
Test Result:

The test result shows the TSI works well with different gloves and no false touch when the user is not wearing gloves.

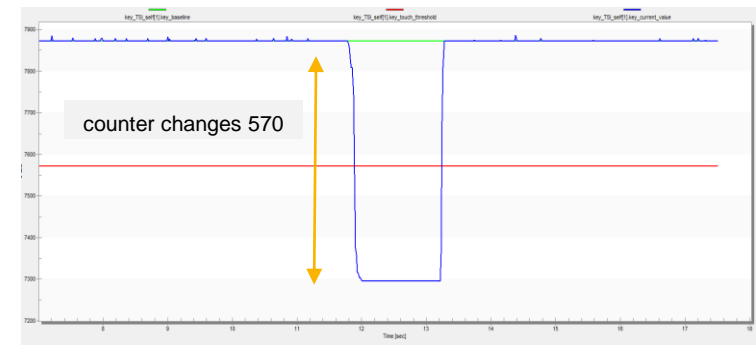
Plastic glove



Rubber glove



Not wearing glove



FAQ for KE15Z Touch Sensing

- **Q: Robust? IEC61000-4-2,-4-4,-4-6(ESD, EFT, Current injection)?**

A: As shown in the previous slides, we've got -4-6 certification

Pass system level -4-2, -4-4 test, result: -4-2, pass +/- 12KV, -4-4, pass +/- 4KV

- **Q: Waterproof?**

A: Passed salty water test, no mis-trigger. Will test other liquid tests (juice, oil, cleanser essence)

- **Q: Sensitivity?**

A: 10mm thick overlay(Acrylic)

S/R and sensitivity configurable by SW

- **Q: Touch recognize time?**

A: HW scan time for one channel is ~100us

- **Q: Development support? HW/SW/Tools?**

A: Touch electrode schematic symbol/layout, NXP Touch library, SDK, FreeMASTER

- **Q: Available time?**

A: Launch in China FTF, 27th Sep. PK Samples and evaluation board are ok now

Q & A



SECURE CONNECTIONS
FOR A SMARTER WORLD